”BABEȘ BOLYAI” UNIVERSITY OF CLUJ-NAPOCA

FACULTY OF GEOGRAPHY

The Water Resources of Rivers from the Transylvanian Subcarpathians between Târnava Mare and Niraj and the Neighbouring Mountainous Region

-Summary-

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Summary

Keywords: water resources, discharge regime, type, subtype, Transylvanian Subcarpathians, Moldavo-Transylvanian Carpathians.

The hydrogeographic study of a region or of a hydrogeographic basin usually consists of a set of empirical and statistical analyses of the components of the natural environment, to which is added, lately, the increasing role of the antropic factor.

The classic order in which such an analysis is carried out has in mind the role of each component to the formation and evolution in time of the water resources of the rivers, that is their contribution seen in a genetic-evolutionary perspective.

Since a a hydrogeographic basin is a better candidate than other natural spatial entities to the aplication of the general theory of the systems, we have chosen as study area the territory which, although includes two distinct geographical units, overlaps the superior basins of Târnava Mare, Târnava Mică and Niraj. These spatial entities have more precise limits, a rather dense network of observation points and measurements, which offer the possibility of the quantitative determination of the hydric output of the system and the possibility of assimilating the entire hydrographic network with an oriented model, in the shape of a tree, whose extreme peaks are represented by brooks, the internal confluence points, and the branches are represented by the linear elements of the network, thus making possible the study of the network by means of mathematical relations.

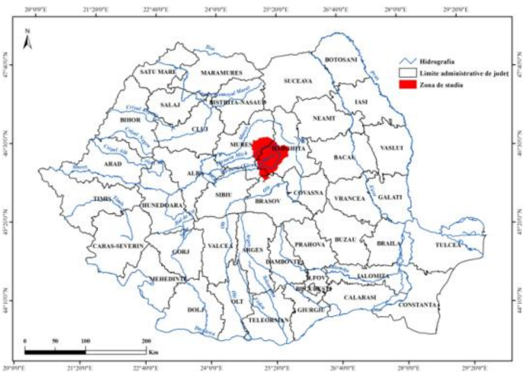


Fig.1. *The geographical position of the region within Romania*

CHAPTER I

I.1. The geographical position and the region limits.

The studied region lies on a 2679 km^2 area in latitude between the 46^0 02' and the 46^{0}43' parallels, and in longitude between the 24^{0}45' şi 25^{0}35' meridians. (Fig. 1.).

Within Romania, the studied region is situated in the Central Northern part, overlapping an area corresponding to the central and northern part of the Transylvanian Subcarpathians and to the western part of Moldavian-Transylvanian Carpathians (partially Gurghiu and Harghita). Fron a hydrographic perspective, the region is integrated in the hydrographic system of the Superior course of Mureș river, corresponding to the basins of Târnava Mare, Târnava Mica and Niraj. (fig.2)

This setting, the altitude and the exposure of the relief to the advection of the air masses from the west has as an effect the decrease of the quantity of rain from North to South, respectively it separates from east to west, with implications in the spatial distribution of the potential of river discharge. The relationship of dependence between the distribution of climatic elements and the altitude is significant in the case of air temperature as well. Thus, in the higher area in the east, the climate is moister and cooler.

I.2. Elements of regional integration and territorial unity

The studied region contains large surfaces from two distinct geographical subunits: the Transylvanian Subcarpathians and the Moldavian-Transylvanian Carpathians (Fig. 2). This fact determines a great diversity of the geographical conditions with multiple implications over the formation and evolution in time of the water resources of the rivers which cross them.

The separation of the geographical subunits was made on the basis of several main criteria: geomorphologic and bio-pedogeographic.

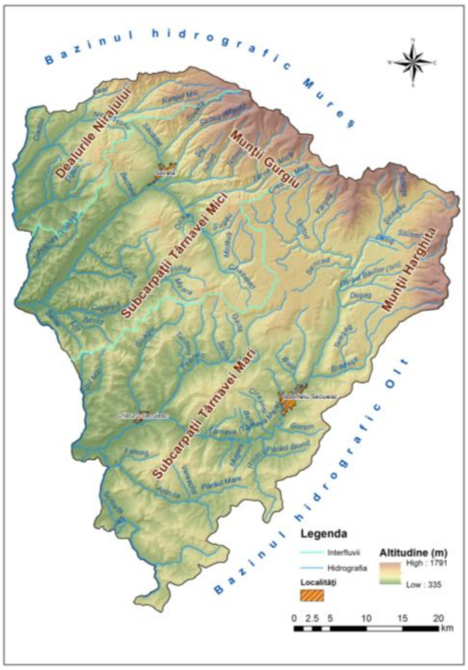


Fig. 2. *The main geographic subunits*

The Moldavian-Transylvanian Carpathians, the name V. Mihailescu (1963) gave to the mountainous region in the central part of the eastern Carpathians, only partly lies within the studied area.

The Gurghiu mountains represent a mountainous subunit which lies between the Niraj Mare valley and the Sucasau valley, the latter facilitating the connection between Odorhei and Giurgeu through Sicaş Pass.

The Harghita Mountains lie within the studied region only with their northern area, which lies between the Şicasău and Brădeşti valleys.

The Transylvanian Subcarpathians, geographical unit of an original subcarpathian type, with certain special specifications in what concerns the genesis, evolution, morphological content and scenery, for which reason a great number of researchers have agreed upon the existence of certain marginal sceneries as compared to the central ones in the Transylvanian Depression ((L. Sawicki, 1912, M.David, 1945 , V. Mihăilescu, 1948.1986), giving this space the name Subcarpathians ((I.Mac, 1968,1972). On the other hand, other researchers (M.Iancu, 1971, I.Sîrcu, 1971, W.E.Schreiber, 1980, Tr.Naum, 1982), on the basis of the rare presence of volcanic agglomerates on a few hills and of the high altitudes in many areas over 1000 m, classify a part of this transition space to the mountainous region.

The geographic subunits of this transition space differ from one author to another. (I.Mac, 1972, Geografia Romîniei, 1987, Gr.Pop, 2001 etc.).

Within the studied region, one can distinguish three geographic subunits, which correspond largely to the hidrographic basins of the three main collectors.

The Târnava Mare or Odorheiului Subcarpathians lie sounth of Feernic, the right affluent of Târnava Mare, all the way to the the interfluve that separates the hidrographic basins of the left affluents (Hodoş, Gorom şi Brădeşti) from the Honorodul Mare basin.

The Târnava Mica Subcarpathians or the Praid Subcarpathians (Geografia României, vol.III 1987, p.602), stretching between the Geoagiu valley and the interfluve between Târnava Mică and Niraj have the smallest width of all the Transylvanian Subcarpathians and the least specific Subcarpathian characteristic.

The Niraj Hills comprised within the interfluve between the Niraj basin and the left affluents of Mureș between the settlements Petelea and Acățari (Beica, Habic, Terebici şi Vaţman), generally exhibit a relief with lower hills and narrower depressions.

CHAPTER II

GEOGRAPHIC CONDITIONS AND THEIR ROLE IN THE FORMATION AND REGIME OF THE RIVER WATER RESOURCES

In the geographic landscape, water, in its various forms, is one of the most important elements, not only by its large spreading, but also by the role that it plays in nature. In many fields of activity, water represents an important prime matter, therefore, insuring that the necessary water exists, both qualitatively and quantitatively, is a contemporary issue, and distributing this resource efficiently can only be done by first knowing the avaibale water resources (Oana Pop, 2010).

In the analysis of the geographic conditions, we applied the deterministic way. (V.Sorocovschi, 1966, p.15).

After identifying the functional or correlational relations between factors and components, we have learnt that the climatic factors play the main role, in that they determine the quantitative and temporal variations of the water resources of the rivers. The other components of the environment (geology, relief, vegetation and soil) play a secondary role, representing the general background to the formation of river discharge. In the general system of the interactions between geosystemic components, the role of the anthropic factor has become more and more significant, and lately even determinant both in the formation of water resources as well as in setting the hydric regime.

II.1. The role of geological conditions in forming water resources.

Studying the geological map (Fig. 4) within the studied area, we notice that more than 75% of it is made up of sedimentary rocks formed from marls/shales, gritstones and tuffs. At the same time, 22% of the area is covered in rocks made from loamy marls, sands and tuffs, while only 3% is represented by the volcanogenic sedimentary rocks. Thus, in the mountainous sector, made up mostly of hard rocks which are highly resistant to erosion (eruptive rocks) the discharge speed is high and the solid debit is insignificant. Moreover, in the depressionary area the discharge speed decreases and the debit can have significant values.

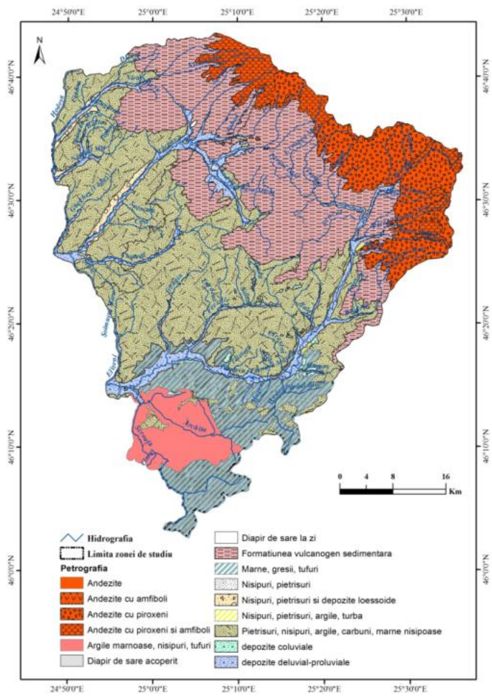


Fig. 4. The geological map (after the map plates 1:200.000)

II 2. The role of relief in forming water resources

The influence of relief is manifested directly through its morphometric particuliarities, and indirectly through the vertical zonality of the main climatic elements, vegetal associations and edaphic cover. Through its geomorphometric characteristics, the relief differentiates subtly the conditions of reception, accumulation and movement of the waters originating from rainfall and snow melting.

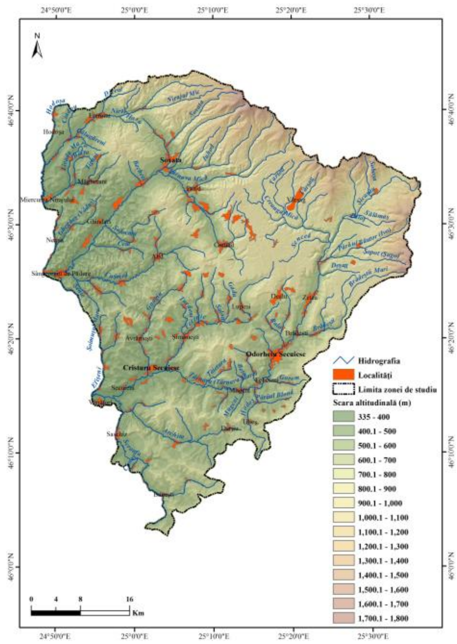


Fig. 5.The hypsometric map

The main geomorphometric indicators which greatly influence the development of the processes and the phenomena linked to the surface and underground discharge are: altitude, slope, fragmentation and orientation of the mountain sides.

The greatest part of the rivers water resources formation process, influenced directly and indirectly by altitude, occurs on the altitude zone between 400 and 1000m.

The relief *slope* represents one of the most important factors of controlling the surface and underground liquid discharge. This factor sets the direction and discharge speed of the water resulted from rainfall or snow melting. The variation interval of the real values of slopes is between 1 and over 35 ^{0} (Fig. 7).

Low values of the relief slope under 7^0 can be found in the valley corridors and the larger depressions within the Subcarpathian region. In the mountainous area low slope values are characteristic to the interfluvial areas of the volcanic plateau, where it has remained relatively intact, being slightly fragmented by the hydrographic network. The low slopes of the surface of the plateau are in sharp contrast with those of the valleys in this morphological layer, which are rather deepened in the deposits of volcanic agglomerates. Here the declivity cann reach level as high as 35 ^{0} sometimes.

The *energy* of the relief is an important geomorphometrical indicator, contributing to the acceleration of superficial discharge towards the main collectors. The depth of the fragmentation of the relief (Fig. 9) has, in general, values that are inverse to those of the density of the fragmentation. The highest values of the energy of the relief can be seen on the south-western sides of the Gurghiu Mountains and on the north-western sides of the Harghita Mountains. In the Subcarpathian region the values of the energy of the relief remain between 100 and 250 m, and decrease only in the large depressionary areas.

The *orientation* of the sides plays an important role in the evolution of the hydro-climatic phenomena, especially in the spatial distribution of atmospheric rainfall. In the area corresponding to the volcanic plateau the quasi-horizontal surfaces are predominant, which leads to the conclusion that the differences in what concerns the duration of insolation are insignificant. Within the affluents of Târnava Mare which have a north-south or north-east-south-west direction, (Şicasău, Pârâul Anei, Pârâul Caprei, Tartod etc.)., the opposite sides exhibit no striking difference from the point of view of the insolation received, still the heat is at a higher level in the case of sides with western and south-western exposure.

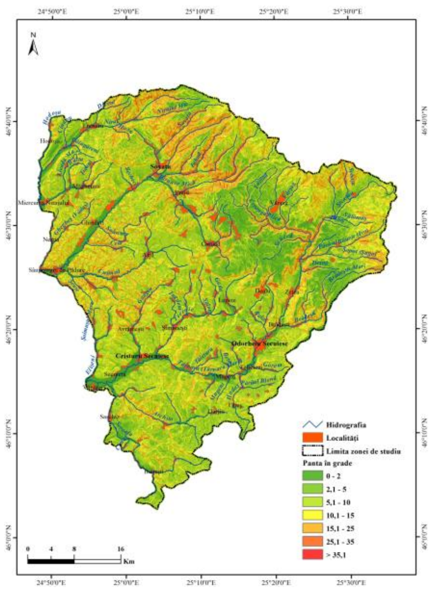


Fig. 7. Map of slopes

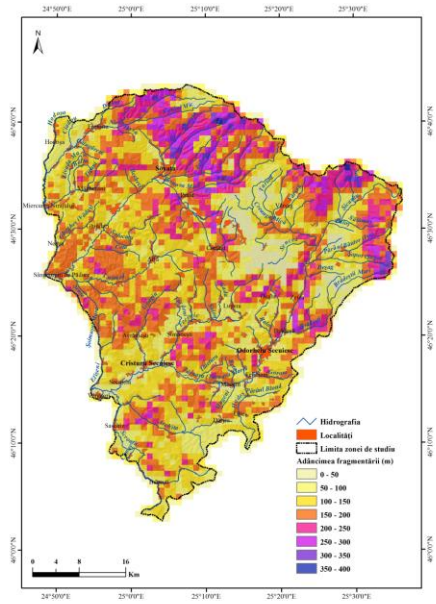


***Fig.9**. Map of energy intervals of relief*

II.3. Climatic conditions and their role in the formation of water resources

Solar radiation. Throughout the year, we can notice an increase in the values of the global solar radiation from January ((3,5 kcal/cm^2) until July when the highest values are recorded **(15-16** kcal/cm^{2,}**),** which determine the intensification of the evapotranspiration process and the production of convectional rainfall. After July the values decrease gradually, reaching the lowest values in the month of December, when nebulosity is high and the duration of days is smaller.

The circulation of the air masses. The movement of the maritime-polar air masses is oriented on the west-east direction and occurs at the same time as the families of Atlantic cyclones, the winter is relatively soft and moist, and the summer is cool and highly unstable. One thier obstruction, either by can also notice both the direct polar circulation, as well as the reverse one or the tropical one which has a low frequency. The presence of the carpathians in the eastern side is manifested by changing trajectories or by disturbing the vertical structure of the baric field.

The orographic cyclogenesis signalled within the Transylvanian Depression with a high frequency in the interval October-April (Elena I. Bordei, N.I.Bordei, 1970) generates short-term local rainfall.

II.3.1. Rainfall

On average, the values are set between 700-800 mm. Looking at the distribution of rainfall over time, we noticed that the highest quantities fall during the summer, and in the case of stations near mountain chain, we can find higher values in the spring as well (Fig.13). Thus, in spring there occur torrential rainfall whose effects are damaging by the sudden level increase, changes of the water courses, intensification of erosion etc.

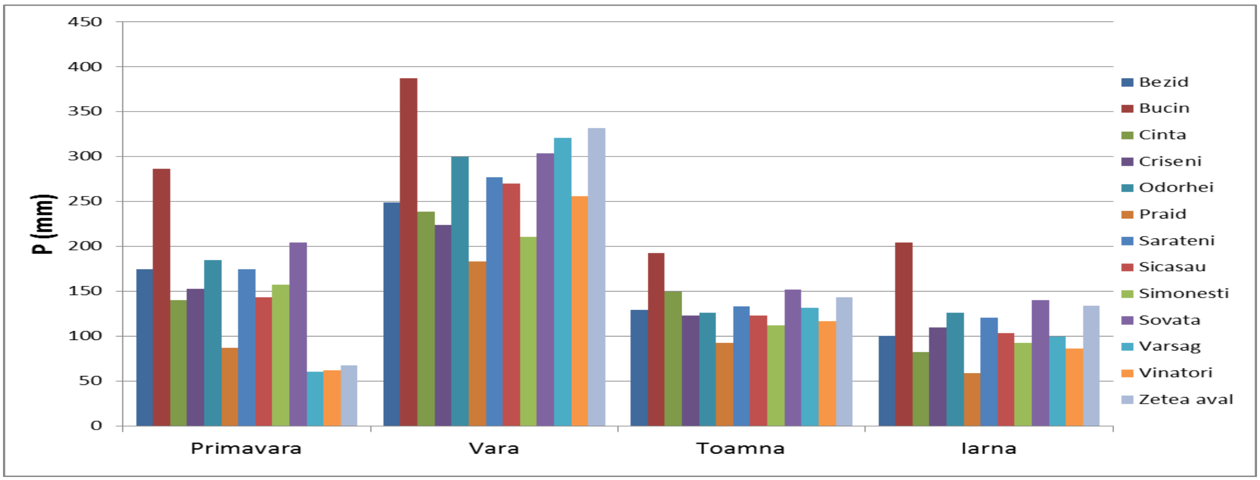
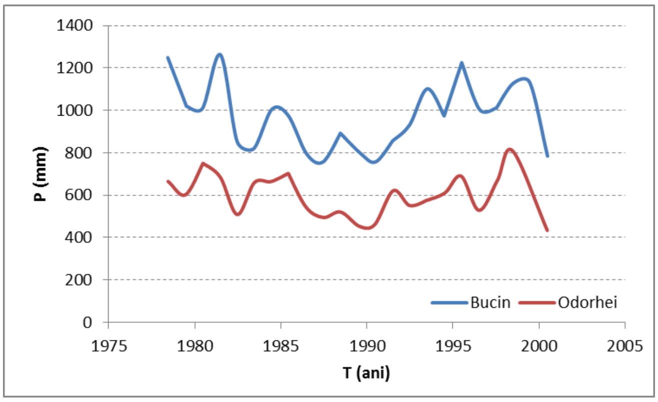


Fig. 13. Variation of seasonal rainfall

An interesting fact in the case of stations Vârşag, Vânători and Zetea is that the lowest seasonal values are not linked to the winter interval, but to the spring one. In the case of the rest of the stations, the lowest values occur in the winter interval. In the case of the weather station Bucin, the only pluvio mountainous point, the lowest value is linked to the autumn interval.



We can see that there is a certain routine of the droughty years, respectively of the rainy ones, both in the mountainous as well as in the Subcarpathians region, being closely influenced by the dynamics of the baric centres.

Fig. 16. Variation of average yearly rainfall at the weather stations Bucin and Odorheiu Secuiesc (1978-2000)

The intensity of rainfall plays an important role because it represents the main source of catastrophical floods.

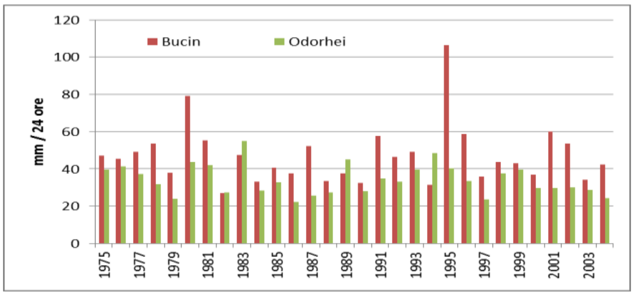


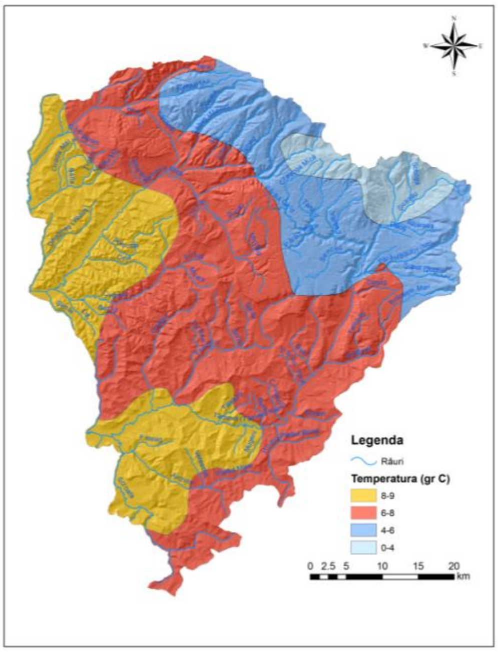
Fig. 17.*Variation of maximum rainfall over 24 hours at the weather stations Bucin and Odorheiu Secuiesc (1978-2000)*

We must emphasize the fact that there are cases when the maximum water quantities that fall over 24 hours are higher than the multiannual average quantities of the respective month, and in exceptional cases are close to the multiannual average values of yearly rainfall.

Snow constitutes an important reserve of water which accumulates on the soil in the winter in the form of the snow layer. Because of its physical properties, the snow layer influences the thermic regime of the air, causing the diminution of air temperature and thus favouring the intensification of thermic inversions.

The regime of the duration of the snow layer (80-120 days/year in the mountains, 70 days/year in the depressions or low hills) depends both on maintaining temperatures under 0°C as well as on the falling of precipitations in the form of snow. That is the reason for which the limits of the interval with a snow layer generally coincide with the dates of the first and last snow fall. Precipitations in the form of snow generally fall starting the middle of November. The snow layer is formed when the soil is frozen and after analyzing the existing nivometric data, we can notice a gap of 10-15 days between the first day with snowfall and the first day with a stable snow layer. The last snowfalls usually occur on average between the second half of March and the beginning of April.

II.3.2. Temperature



The average annual temeperature is remarked by values of 7-8 °C in the depressionary areas from the Transylvanian Plateau and goes low as 7 °C in the higher hills and in the Subcarpathian depressions.

Fig. 18.The average multiannual temperature (1961-2000) after Clima României 2008

II.4. The role of vegetation in the formation of the discharge

Depending on the influences of altitude, one can distinguish two distinct areas, that of forests and the alpine one. The forest area, much larger, covers 18%. The alpine area, represented by the subalpine layer (of bushes and glades) covers a small area of the mountainous region, representing less than 1% of the surface of the studied region.

The forestation degrees on Târnava Mare and Târnava Mică are relatively close and less poignant in the Niraj basin. The influence of deciduous forests is more obvious in their vegetation period. The effect means that the minimal discharge increases in the droughty periods in summer and winter. It has been observed that at average basinal altitudes between 500 and 900 m and reception surfaces larger than 400 km^2, a 5% increase in the forestation coefficient generates an increase in the annual average discharge with 1 ls.km^2, and of the minimum monthly discharge with approximately 0,4 1 ls.km^2. In addition, we have observed that on Târnava Mică, whose basin is much better afforested in the mountainous area, the total average durations of floods are longer than those on Târnava Mare, in sections situated at equal lengths from the spring.

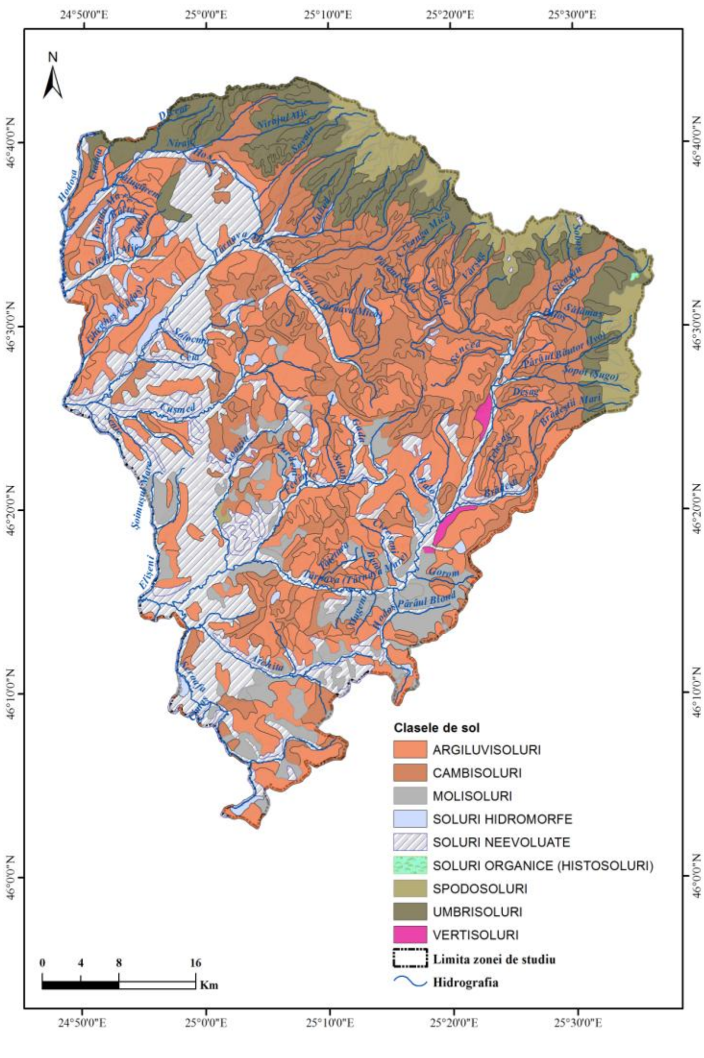


Fig. 23 Types of soils

II.5. The role of the edaphic factor in the formation of dicharge

Soils have an important role in the process of formation of superficial discharge and in that of supplying, through the infiltration of underground waters, acting as an intermediary between the climatic factors and discharge.

Clay soils have a low infiltration coefficient (especially albic soils) which favours the increase of superficial discharge, due to the lack of vegetation.

The values of the discharged water layer are in close connection with the type and characteristics of soils, being lower in the case of mellow soils, with consistent texture, and higher above waterproof soils, with fine clay texture, as well as in the case of those of low depth.

II.6. The influence of the anthropic factor over the conditions of formation and evolution of the water resources of rivers

Anthropic activities have an increasingly important role in the formation and evolution of the water resources of rivers. Thus, the way of using fields, the arrangement of storage lakes, various works of water-course regulations, damming and consolidation of the banks, of land improvements or any works regarding the water supplied to the population, industry etc., as well as the network of settlements and roads, have all left their mark on the formation of both surface and underground water resources.

II.6.1. Means of using field

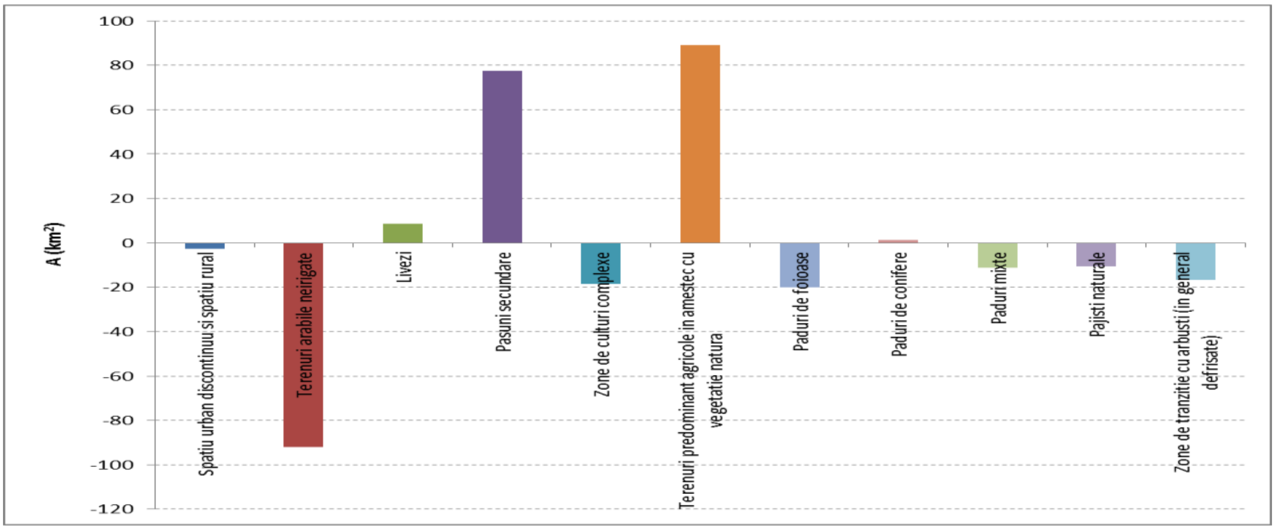


Fig.26. Changes in the means of using field between the years 2000 and 2006 (according to the database Corine Land Cover 2000 and 2006)

Analysing the structure highlighted by the Corine database from the year 2004 and comparing it to the one in 2000 we notice constant decrease in the spread of areas covered in woody vegetation, as a result of the exploitations of the forest, but also a reduction of the natural grassplots, the anthropic pressure through the extension of agriculture being obvious. This results in the increase of superficial discharge, the increase of the diversion coefficient, but also of the increase in floods and decrease in their raising time.

II.6.2. Storage lakes

Of all the effects on the discharge regime, the most important one has been the construction of storage lakes. Thus, on the main collectors or on some main affluents, two types of storage lakes were built (permanent and temporary).

The permanent storage lakes constructed on Târnava Mare (Zetea) and on Cușmed (Bezid) were built with the purpose of diminishing flood waves in the periods with high waters, of supplementing water discharge in periods of low waters, of supplying water to various consumers downstream and to a smaller extent, for the production of electricity (table 6). The important role is that of diminishing flood waves (table 6).

Table 6. *The volumes and functions of permanent storage lakes*

Denomination of storage lake	**Water course**	**Total volume (mil. m^3)**	**Used volume (mil. m^3)**	**Alleviation volume (mil. m^3)**	**Category of use***
Zetea	Târnava Mare	43	14,4	26.5	Supl. Q, N, A
Bezid	Cuşmed	31	14	16	Supl. Q, E, N

*Supl. Q – supplimenting of discharges; N/- flood alleviation; E- energy production; A water supplying

Table 7. Characteristics of temporary storage lakes in the hydrographic basins Târnava Mare and Niraj

Denomination of storage lake	**Water course**	**Type of dam**	**Height of dam (m)**	**Year of construction**	**Total volume (mil.m^3)**
Vânători	Târnava Mare	Deversor din beton	24	1984	25
Valea	Niraj	Deversor de arocam.	14	2005	6

II.6.3. Hydrotechnical works of regulation, damming and banks consolidations

Over time, the network of rivers has suffered changes due to the many hydrotechnical works for the protection of river banks and beds, which have included cutting meanders, directing currents, closure or clogging traverses, consolidating banks. Transverse works on the river bank are found on Cușmed and Niraj.

Works of regulating the river bed were done on both banks of Târnava Mare and on some affluents. Following the catastrophic flooding of May 1970 several hydrotechnical works of protection of banks and regulating the riverbed were carried out in the Niraj basin.

On the rivers in the studied region, the dams are associated with works of regulating the riverbed. Such situations can be found in the cities Odorheiu Secuiesc (1.96 km) and Cristuru

Secuiesc (1.3 km) on Târnava Mare and in some settlements situated on Târnava Mică (Ghindari, 2.4 km, Sângeorgiu de Pădure, 1.05 km).

II.6.4. Works of land improvement

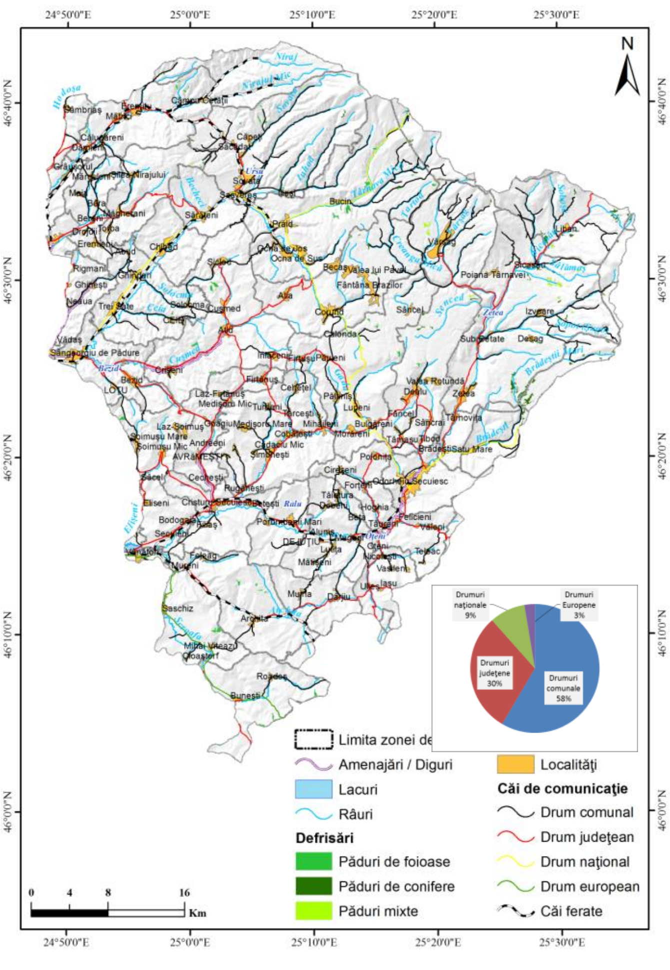
The antierrosive agrotechnical works carried out especially in the subcarpathian region included terracing and planting fruit trees, afforestation of the mountain sides with steep slopes etc. In the hydrographic basins belonging to Târnava Mică (Sovata valley) and Niraj dams of annihilating torrents were built in order to regulate water debits and fix land.

II.6.5. Water uses

Having in view the volume of water collected by various uses we learnt that industrial uses are on the first place, owning over half of the total collected volume. Next in order are the uses that require drinkable water (32% of the total collected volume) and at great distance are agricultural uses (3% of the total collected volume).

For example, the town of Odorheiu Secuiesc is supplied with water in centralized system at a flow of 400 l/s. Unfortunately, the systematic use of water for agriculture is made only rarely.

II.6.6. The network of settlements and roads



The density of the roads network within an area together with the network of settlements represents an important indicator as to the degree of its population degree (Fig. 34). The average value of the density of the roads network after taking into account all the roads including the communal ones, reaches the value of 0.545km/ km^2

Fig. 34 The network of means of communication and settlements.

Chapter III

ASSESING THE POTENTIAL OF RIVER WATER DISCHARGE

The water resources of rivers represent an important component of water circulation in nature. The quantitative and qualitative awareness of this component is of great importance in assesing the possibilities of its use in different fields of activity. The cycle of water can be considered a system, in which the input is represented by rainfall, and the output is represented by discharge and evaporation.

Special attention is paid to the quantitative and dynamic research of the substance input and output within the system. Of the two usual approaches, sequentially for each system component or integratedly, we have considered that the second is the most adequate and can be done by means of the hydric balance method, which offers the possibility of encompassing the whole system with the help of mathematical equations, which later allow the drafting of various models (physical, analogical or mathematical), which were included in two main categories: stochastic and deterministic (R. P. Ybbit, 1971).

III.1. The organization and morphometrical characteristics of rivers

The studied area is part of the hydrographic basin of Mureș and can be divided into three main sub-basins: Niraj, Târnava Mare and Târnava Mică. The shape of the longitudinal profile is of major importance in identifying the potential floodable areas, present mostly at the bending of slopes, at the point of entrance of rivers in depressions, or ahead straits such as the one at Oțeni, for instance. Likewise, from the longitudinal profile we also notice the river sections prone to erosion, in the higher parts, or to sedimentation, in low slope sections, where there are also areas of high hydrographical network density, the so-called areas of convergence (The Depression Niraj, Praid, Odorhei). Statistically, 61% of the basin surface has values below 0.5 km/km^2. The highest value is 4.8 km/km^2, but covers only a 0.01% area.

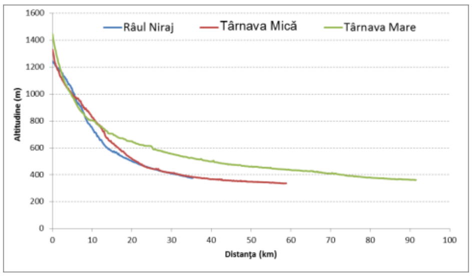


Fig. 35. *Longitudinal profiles on the main rivers*

The known coefficients linked to the form of the basin (Table 11) exhibit a similarity between the basins chosen for analysis. As it is well known, the shape of the hydrographic basins represents an indicator which is reflected in the influence upon the periods of concentration of waters to the collecting river.

Table 11. The shape coefficients of the main hydrographic basins.

Name of hydrographic basin	Surface km^2	Perimeter km	Development coefficient of the watershed	Circularity coefficient	Shape ratio
Niraj	289	108	1.8	3.6	0.4
Târnava Mica	842	166	1.6	2.1	0.5
Târnava Mare	1548	250	1.8	2.6	0.4

III.2. Hydrometric activity and research history

In order to assess river water resources it is necessary to have a series of data which are extracted from the measurements conducted by the specialists of different Basinal Administrations under the authority of the National Administration of Romanian Waters. The hydrographic basins appropriate to the studied region are integrated to the Basinal Administration of Waters Mure;, and the data resulting from measurements are centralized in Tâargu Mureş.

In order to assess the water resources of rivers and their discharge regime we have examined and processed rows of daily, monthly and annual average flows from 13 hydrometric stations (fig. 33), which control the hydrographic basins whose altitude oscilates between 570 and and 1.021 m, and the surface between 15 km ^{2} and 1771 km ^{2} (table 12).

Table 12. Periods of observations from hydrometric stations.

River	Hydrometric station	Surface (km^2)	Average altitude (m)	Date of construction	Period of direct data	Extended period	Q (m^3/s)
Niraj	Cinta	555	512	1970	1970-2012	1950-1969	3.558
Târnava Mică	Sovata	83.8	872	1980	1980-2012	1950-1979	1.586
Târnava Mică	Sărăţeni	447	881	1970	1970-2012	1950-1969	6.206
Cuşmed	Crişeni	98	582	1991	1991-2012	1950-1990	0.544
Bezid	Bezid	15	523	1992	1992-2012	-	0.092
Târnava Mare	Vărşag	106	951	1970	1970-2012	1950-1969	1.532
Târnava Mare	Zetea	361	1.021	1990	1990-2012	-	3.972
Târnava Mare	Odrohei	657	893	1983	1983-2012	1950-1982	5.707
Târnava Mare	Vânători	1.771	680	1970	1970-2012	1950-1969	9.225
Şicasău	Şicasău	112	1025	1982	1982-2012	1950-1981	1.405
Hodoş	Nicoleşti	46	624	1986	1986-2012	1950-1985	0.253
Feernic	Şimoneşti	145	683	1970	1970-2012	1950-1969	0.868
Scroafa	Saschiz	190	570	1982	1982-2012	1950-1981	0.577

In the analysis of average annual discharge we have used three calculation periods with intervals of 63 years (1950-2012), 43 years (1970-2012) and 21 years (1990-2012) which has allowed not only to compare them, but also to set the degree of representation for the studied region. For this we were obliged to extend the series of monthly and annual average flows up to the year 1950 (table 14). The extension was made on the basis of extension relations determined with the help of graphic and chart correlations.

In order to characterize the discharge flow of rivers we have chosen the period 1992-2012. In choosing this period we took into account several criteria the specifics of the line of hydrometric data, the necessary precision for the variability of the data rows, presenting several advantages: the length of the data series is sufficient; it exploits exhaustively the existing hydrometric data, inluding the most recent and certain ones; it presents the smallest errors of the average discharge and of the variation coefficients, enclosed within the admissible limits.

The complex of observations and measurements regarding weather, river status, vegetation, rainfall, the snow layer (thickness and density of the layer of snow, the water reserve in the snow layer), frost phenomena (measuring the thickness of snow on ice, measuring the thickness of ice), liquid flows, suspended alluvial flows, sediments in the water bed.

In the analysis of the hydrometric network (Fig. 36) we had in mind several criteria: distribution on main hydrographic basins, according to the surface of the controlled reception basins, on altitude levels etc.

Of the total stations, eight are set in the Târnava Mare basin, four in the Târnava Mică basin and one on Niraj. Over short periods of time there have existed two more stations on Târnava Mică in Sovata and Sângeorgiu de Pădure (1950-1957). Most station which control surfaces below 150 km^2 have a life span of over 16 years.

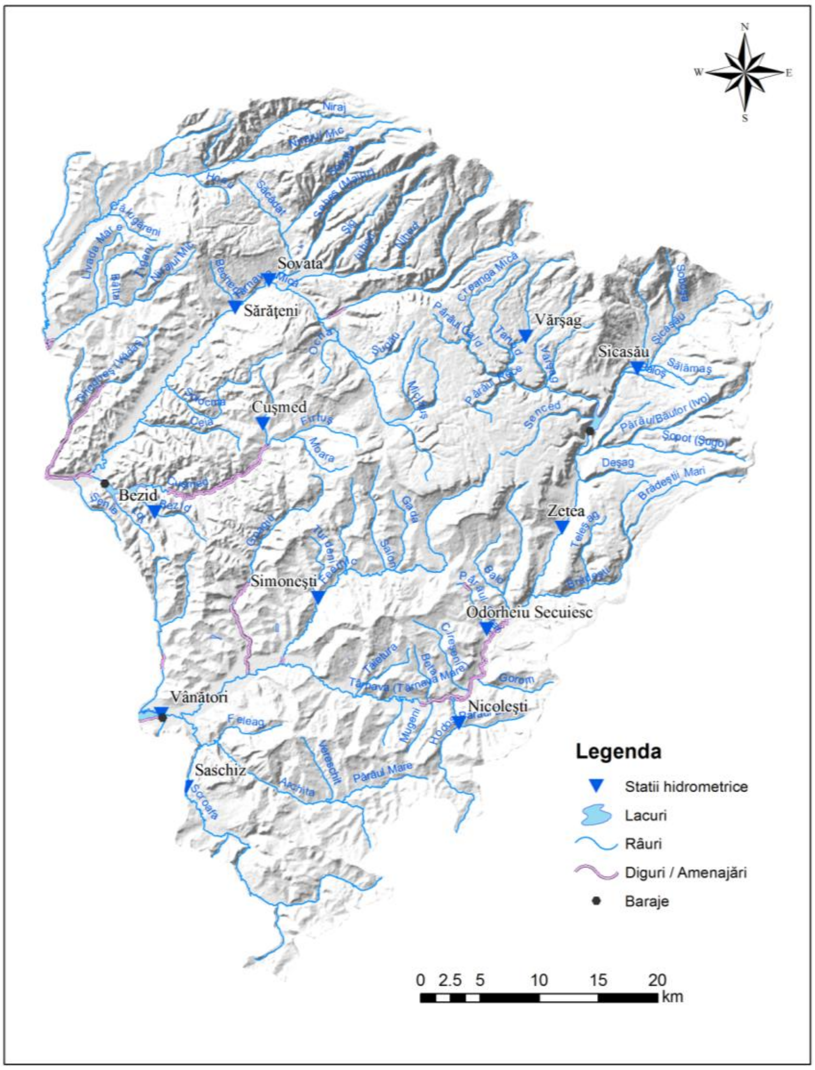


Fig. 36 *The hydrometric network of the studied area*

From antiquity, people have considered water to be an absolute necessity, building their houses close to water courses in order to facilitate access to water. Satrting as early as the 17th century people's need to defend themselves against flood led to the construction of hydrological stations, dams and temporary storage lakes.

The hydrographic network of our country has been studied by many specialists, by determining the influence of physical-geographic factors on the discharge, determining the density of the hydrographic network etc. (T.Morariu, Al. Savu, 1954), determining the slope of the river and finding the connections between the slope and the density of the hydrographic network, the relations between the water flows and the size of rivers etc. (Gh. Platagea, Gh. Popa, 1963).

In what the regional limnology is concerned, results have been obtained in the regionalization of the characteristics of the thermic and hydrochemical regime (P. Gâştescu, 1963; P.Gâştescu, 1970, I.Pişota,1971, Ariadna Breier, 1976).

The concept of hydrogeography is approached by geographic issues attributed to the study of waters by specialists in the field, P.Gâştescu (1970), P.Gâştescu and collaborators (1967, 1976). I. Zăvoianu in his paper "Morfometria bazinelor hidrografice", (1978) shows the relations that exist between the morphometric elements of river beds and of the hydrographic basin.

In the river domain we can mention: the sources of river supply (Ujvari I., 1957, Lăzărescu D., Panait I. 1957), the density of the hydrographic network (Ujvari I. 1956), types of river regime (Ujvari I. 1956, Lăzărescu D., Panait I. 1957), the distribution of the liquid discharge over seasons, the minimal discharge and rivers dry out (Ujvari I. 1958, Diaconu C. 1961), the maximum discharge and floods (Diaconu C. 1961, Mustață L. 1973), the specific average discharge (Diaconu C. 1954), the heat and frost regime (Diaconu C.), the hydrologic balance (Ujvari I. 1957, Lăzărescu D., Panait I. 1957), the prognosis of the hydrological phenomena (Lăzărescu D. 1972).

Great contributions to the study of liquid discharge in the Romanian speciality literature were made by the authors: Gâștescu P. (1986, 2003), Diaconu C. (1961, 1962, 1969, 1973, 1987, 1994), Sorocovschi V. (1977, 1986, 2003, 2008), Pandi G., Moldovan F. (2003), Zaharia Liliana (1995), Romanescu (2003, 2004). We shall also mention a few international authors: Lvovici M. (1979), Stelczer K. (2000), Starosolszky O. (1987) etc.

In the study of the process of discharge it is important to mention the combinations between temperature and rainfall in relation to the discharge (humidity) deficit which represents the fraction of water fallen on a certain area and which does not go into rivers. The importance of this calculation lies in the fact that one can determine the discharge deficit, respectively the liquid discharge in regions in which we cannot obtain direct hydrometrical observations (Sorocovschi, 2010. pg.130).

Over the past years, a series of Ph.D. theses guided by Professor Victor Sorocovschi have dealt with the issue of water resources. The modern methodology applied in those theses, which uses GIS technology at the sametime as the traditional methodology of assessing water resources, emphasizes them. We mention: „Studiul scurgerii lichide din bazinul hidrografic Tur" by Oana Pop, „Studiul Lacurilor de acumulare din bazinul superior al Crişului Repede" by Horvath Csaba, „Studiu de hidrologie urbană în culoarul Mureşului dintre Reghin şi confluenţa cu Arieşul" by Hadrian-V. Conţiu etc. We also mention several important papers, such as: „Implementarea G.I.S. în modelarea viiturilor de versant" by Ştefan Bilaşco and „Scurgerea lichidă şi solidă în Subcarpaţii de la Curbură" by Viorel Chendeş.

III.3. Methodological aspects regarding the assessment of river water resources

In order to determine the normal hydric balance of a hydrographic basin, we must have several elements: the multiannual average rainfall (X_0), which is determined on the basis of pluviometrical data by the method of annual normal izohiets; the total normal discharge (Y_0) which is determined by one of the methods mentioned; the normal underground discharge (U_0) is determined by separating the underground discharge on the discharge hydrographs; the normal superficial discharge (S_0) is obtained as a difference between the total normal discharge and the normal underground discharge ($S_0 = Y_0 – U_0$); the normal evapotranspiration (Z_0) is determined as the difference between normal rainfall and total normal discharge ($Z_0 = X_0 – Y_0$).

The most valuable results are those obtained by I. Ujvari (1972), who, by applying the equation drafted by M. I. Lvovici obtained for all the hydrographic basins in Romania the values of all balance components. Also, he calculated the hydric balance of the Danube.

Table 13. The values of the components of hydric balance (1950-1969) (acc. to Geografia României, I , 1983)

Territorial unit		**X_0**	**Y_0**	**η**	**S_0**	**U_0**	**Z_0**	**W_0**
Carpaţii	mm km^3	807 63	327 25,5	0,4	222 17,3	105 8,2	480 37,5	585 45,7
Regiunea pericarpatică	mm km^3	589 94	69 11	0,1	48 7,7	21 3,3	520 83	541 86,3
România	mm km^3	661 157	153 36,5	0,2	102 25	51 11,5	508 120,5	559 132

From the analysis of the global hydric balance (in Romania), we learn that of the total rainfall (661 mm) the greatest part (77%) i.e. 508 mm is consumed through evapotranspiration and only 153 mm (23%) through liquid discharge (table 13).

III.4. Assessment and distribution of the average discharge potential

Average discharge is the most general indicator of river water resources. It offers the possibility to measure the water potential of rivers from a certain region, being useful in all researces meant to study the possibilities of rational valorification of water for various social-economical purposes.

III.4.1. Assessing annual average discharge

In the quantitative characterization of discharge, we used a series of terms: medium flow (Q – m^3/s) and discharge volume (V – mil. m3), which offer the possibility to characterize the potential of discharge concentrated on river beds; the means of discharge or specific discharge ($l/s.km^2$) and the height of the discharge layer (Y – mm) allow for the characterization of water resources on a certain field and comparing them with others.

Table 15. Basic data regarding multiannual average discharge (1992-2012)

River	Hydrometric station	Surface (km^2)	Average altitude (m)	Q (m^3/s)	q ($l/s.km^2$)	V ($mil.m^3$)	Y (mm)
Niraj	Cinta	555	512	3.542	6.382	111,7	202
Târnava Mică	Sovata	83.8	872	1.528	18.223	48.2	575
Târnava Mică	Sărăţeni	447	881	6.110	13.668	192.7	431
Cuşmed	Crişeni	98	582	0.658	6.714	20.7	211
Bezid	Bezid	15	523	0.092	6.133	2.90	193
Târnava Mare	Vărşag	106	951	1.807	17.047	56.98	537
Târnava Mare	Zetea	361	1.021	3.972	11.002	125.26	347
Târnava Mare	Odrohei	657	893	5.749	8.750	181.30	276
Târnava Mare	Vânători	1.771	680	9.613	5.428	303.15	171
Şicasău	Şicasău	112	1025	1.435	12.812	45.25	404
Hodoş	Nicoleşti	46	624	0.253	5.434	7.88	171
Feernic	Simoneşti	145	683	0.944	6.514	29.77	205
Scroafa	Saschiz	190	570	0.562	2.957	17.72	93

In choosing the period of study for the average discharge we had several criteria in mind: the particuliarities of constituting the series of hydromatic data; the precision necessary for the knowledge and variability of data series.

The representativity of the data series was analysed on the basis of flows determined for three periods at the lenghts of 63, 43 and 21 years (table 16). Having in view the criteria mentioned we chose for the calculation of average discharge the period 1992-2012, which offers several advantages: the length of the data series is sufficient; it fully exploits the existing hydrometric data, including the most recent and certain ones; it presents the smallest errors of average discharge and variation coefficient, within admissible limits.

The period 1950-2012, although it exploits the data from a rather large number of stations, is not as significant as far as average discharge is concerned because it lacks direct observations throughout the entire period for all stations (Table 17)

Table 17. Periods with observations from hydrometrical stations

River	.Hydrometrical station	Date of construction	Period of direct data	Extended period	Q (m^3/s)
Niraj	Cinta	1970	1970-2012	1950-1969	3.558
Sovata	Sovata	1980	1980-2012	1950-1979	1.586
Târnava Mică	Sărăţeni	1970	1970-2012	1950-1969	6.206
Cuşmed	Crişeni	1991	1991-2012	1950-1990	0.544
Bezid	Bezid	1992	1992-2012	-	0.092
Târnava Mare	Vărşag	1970	1970-2012	1950-1969	1.532
Târnava Mare	Zetea	1990	1990-2012	-	3.972
Târnava Mare	Odrohei	1983	1983-2012	1950-1982	5.707
Târnava Mare	Vânători	1970	1970-2012	1950-1969	9.225
Şicasău	Şicasău	1982	1982-2012	1950-1981	1.405
Hodoş	Nicoleşti	1986	1986-2012	1950-1985	0.253
Feernic	Şimoneşti	1970	1970-2012	1950-1969	0.868
Scroafa	Saschiz	1982	1982-2012	1950-1981	0.577

In general, we notice the diminishing of the discharge gradients, from North to south, in relation to the reduction of rainfall quantity in the same direction and of exposing the territory to the advection of moist air masses from the west.

The correlation between the values of specific average discharge and the average altitude of the reception basins of the studied hydrometric stations has allowed us to identify three curves (fig. 37).

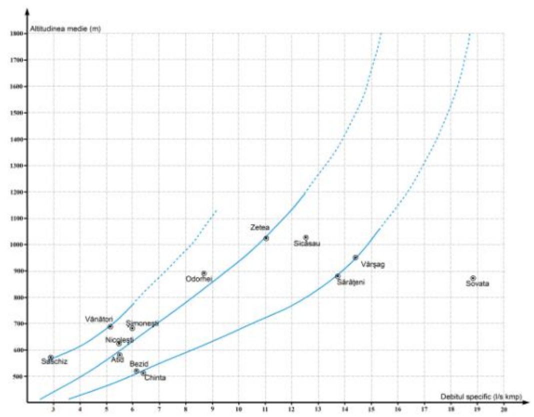


Fig. 37. The relation between the specific average discharge and average altitude of reception basins

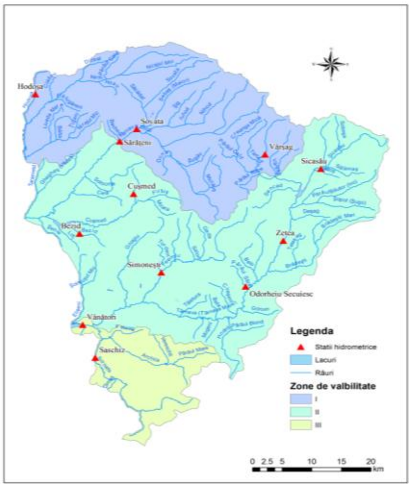


Fig. 38. Areas of validity of the relations q= f (Hmed.)

In the first area, the northern, the high values of the discharge gradients are due to the fruitful exposure of the territory towards the advection of air masses from the west and to the relief slope which is rather steep.

The second area of validity, with lower values of the discharge gradients includes a great part of the Subcarpathian region drained by Târnava Mică and Târnava Mare and a more reduced space corresponding to the Harghita Mountains and to the Southern extremity of the Gurghiu Mountains, drained by the affluents of Târnava Mare (Șicasău, Ivo). The third area of validity, characterized by the most reduced values of the discharge gradients includes a small area which is lower than the southern limit of the studied subcarpathian region, drained by the affluents of Târnava MareȘ Archita and Scroafa.

Depending on the discharge conditions specific to each area of validity of the relation q= f(Hmed) , the increase of the discharge compared to altitude is produced differently (table 18).

On the basis of data obtained after correlating the altitude and the specific flow, we drafted the map of specific average discharge, from which results an increase of values from 4 l/s. km^2 at the meeting point of the Subcarpathians with the Transylvanian Plateau up to 18-20 l/s. km^2 on the higher peaks of the mountains Gurghiu and Harghita (fig. 39).

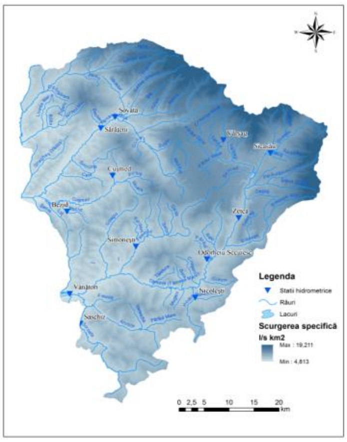


Fig.39. Map of specific average discharge.

III.4.2. Distribution of average discharge potential.

Distribution of average discharge potential implies two distinct aspects: spatial and temporal.

The spatial distribution of average discharge potential

In outlining the particuliarities of territorial distribution of discharge we use the already mentioned indicators, which can be analyzed on intervals of altitude, at the level of hydrographic basins, natural units and administrative units.

Distribution of the average discharge potential on intervals of altitude.

We notice the increase of discharge at the same time as the increase of the relief altitude emphasized also by the different contribution of relief steps to the realization of the average volumee of liquid discharge which depends both on the values of the vertical gradients of discharge, as well as on the surface belonging to the altitude interval.

Over one third of the volume leaked in the rivers in the studied region originate in the altitude intervals between 401 and 600 m. Compared to the surface of 2679.7 km^2, which is the size of the studied area, we obtain a medium layer of 235.5 mm.

Table 19. Distribution on intervals of altitude of the multiannual average discharge in the studied area.

Intervals of altitude (m)	F (km2)	Q (m3/s)	V (mil. m3)	Y (mm)	% of the quantity of water discharged
335-350	12.5	0.006	0.2	16.1	0.5
351-400	101.2	0.236	7.5	73.7	3.8
401-450	175.7	0.530	16.7	95.2	6.6
451-500	262.7	0.937	29.6	112.5	9.8
501-550	303.6	1.289	40.7	133.9	11.3
551-600	294.9	1.438	45.4	153.8	11.0
601-650	243.2	1.364	43.0	176.9	9.1
651-700	182.3	1.190	37.5	205.9	6.8
701-750	132.3	1.004	31.7	239.4	4.9
751-800	129.4	1.145	36.1	279.0	4.8
801-850	140.9	1.399	44.1	313.2	5.3
851-900	109.5	1.220	38.5	351.5	4.1
901-950	133.8	1.651	52.1	389.1	5.0
951-1000	99.5	1.292	40.8	409.8	3.7
1001-1050	60.1	0.829	26.1	434.8	2.2
1051-1100	45.9	0.647	20.4	444.9	1.7
1101-1150	42.3	0.614	19.4	457.9	1.6
1150-1200	48.3	0.721	22.7	471.0	1.8
1201-1250	35.6	0.532	16.8	470.9	1.3
1251-1300	30.1	0.454	14.3	474.8	1.1
1301-1350	27.2	0.412	13.0	477.4	1.0
1351-1400	20.7	0.318	10.0	484.9	0.8
1401-1450	16.7	0.261	8.2	493.3	0.6
1451-1500	11.2	0.180	5.7	506.0	0.4
1501-1550	8.2	0.134	4.2	513.4	0.3
1551-1600	4.8	0.081	2.5	527.6	0.2
1601-1650	3.4	0.059	1.9	536.8	0.1
1651-1700	2.2	0.039	1.2	551.4	0.1
1701-1750	1.2	0.022	0.7	548.4	0.0
1751-1800	0.4	0.007	0.2	529.6	0.0
TOTAL	**2679.7**	**20.012**	**631.1**	**235.5**	**100.0**

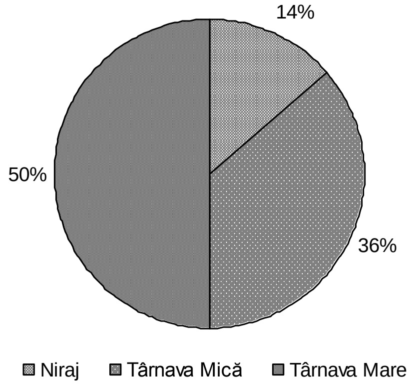


Fig.40. *Ponderea principalelor bazine hidrografice la potenţialului scurgerii medii*

III.4.2.1.2. Distribution of the average discharge potential in the hydrographic basins.

From the analysis of the spatial distribution of the average discharge potential on the three hydrographic basins belonging to the studied area, we learn the fact that half of the discharge volume is carried out in the hydrographic basin of Târnava Mare, and the rest in the hydrographic basins of Târnava Mică and Niraj (fig.40).

The average total flow of the rivers in the studied area has been assessed to 20.613 m^3/s. The average flows of rivers differs depending on the geographical conditions, the size and exposure of the hydrographic basins.

Due to the small territory from which they collect their waters, the affluents of Niraj have low flows, although the exposure of the basins is favourable to the advection of moist air masses from the west.

In the Târnava Mică basin we notice a rather sognificant difference between the larger flows of rivers with reception basisns developed in the mountainous region, and those of rivers with reception basins developed in the Subcarpathian region. The only exception is Cușmed spring whose average flow at flow largely exceeds 0,400 m^3/s.

In the Târnava Mare basin there exist the same contrasts between the flows of rivers with reception basins developed in the mountainous and subcarpathian area. Of the rivers with larger flows, more prominent are Șicasău (1.077 m^3/s) and Feernic (1,088 m^3/s). Over two thirds of the rivers in the Târnava Mare basin have flows lower than 0,100 m^3/s. The explanation lies in the fact that for the largest part of the Târnava Mare basin, the vertical gradients of specific average discharge are low, as a result of the reduction of rainfall quantities in this area.

III.4.2.1.3. Distribution of potential of average discharge on geographic units

The distribution of the potential of average discharge at the level of the main geographic units and subunits was analyzed from two points of view: altitude intervals and globally.

From the potential of average discharge assessed at the level of the studied region of .66 million m^3, more than half is formed in the mountainous region (56 %). The subcarpathian region contributes with a similar percentage (44%) to the realization of the discharge potential in the studied area.

Lower altitude intervals, with low gradients of discharge, as well as high ones, which occupy small areas, contribute to a limited extent to the realization of the average discharge potential.

Table 26. *Distribution of average multiannual discharge on the subunits of the studied area*

Geographic subunit	Average discharge				% of the total discharged quatity of water
	Q (m^3/s)	q ($l/s.km^2$)	V ($mil.m^3$)	Y (mm)	
Târnava Mare Subcarpathians	4.77	4.58	150.49	144.54	25.9
Târnava Mică Subcarpathians	3.00	5.51	94.64	173.88	16.3
Niraj Depression	1.42	6.43	44.64	202.88	7.7
Subcarpathian Region	**9.19**	**5.09**	**289.77**	**160.49**	**49.9**
Gurghiu Mountains	6.90	13.24	217.46	417.41	37.5
Harghita Mountains	2.31	9.48	72.71	298.88	12.6
Mountainous region	**9.21**	**12.04**	**290.17**	**379.68**	**50.1**
STUDIED AREA	**18.40**	**7.16**	**579.94**	**241.00**	

Of the subdivisions of the Subcarpathian region, a great contribution to the volume of water realkized in the studied area is made by the Târnava Mare Subcarpathians.

III.4.2.2. Variation and tendency of average discharge

The variations of discharge from year to year differ from one river to another and from one region to another. The variation degree of annual discharge is determined both by the climatic characteristics and mainly by the degree of humidity, as well as by the surface of hydrographic basins, which play an important tole in the realization of discharge. In order to characterize discharge from year to year, we have used modular, variation and asymmetry coefficients.

Table 27. Characteristical data regarding the variation of annual discharge

River	Hydr. station	K Max.	K Min.	C_V			Characteristic years			
				1950-2012	1970-2012	1992-2012	Sece-tos	F. Sece-tos	Plo-ios	F. ploios
Niraj	Cinta	2.64	0.40	0.41	0.43	0.36	1963	1990	1980 1981	1970
Târnava Mică	Sovata	1.59	0.52	0.24	0.23	0.18	2012 2003	1990	1974	1981 1970
Târnava Mică	Sărăţeni	1.68	0.52	0.27	0.27	0.26	1951 1950	2003 1950	1978 1970	1980
Cuşmed	Crişeni	2.61	0.29	0.49	0.47	0.45	1951 1961	1950	2010	1998 1980
Bezid	Bezid	0.38	0.21	-	-	0.62	2012	1992 1994	2002	1998
Târnava Mare	Vărşag	1.83	0.43	0.29	0.27	0.28	1950 1951	1954	1970	2010
Târnava Mare	Zetea	1.59	0.53	-	-	0.29	1990	2003	2010	2005
Târnava Mare	Odrohei	1.69	0.47	0.27	0.27	0.26	1950 1951	1954	2010 1981	1970

Târnava Mare	Vânători	2.13	0.47	0.34	0.34	0.31	1954 1951	1950 1990	1998 1980	1970
Şicasău	Şicasău	1.63	0.50	0.23	0.22	0.25	1950 2003	2012	1980	1970
Hodoş	Nicoleşti	3.22	0.24	0.66	0.67	0.65	1986 2001	1950 1951	1998	1970
Feernic	Şimoneşti	2.28	0.32	0.44	0.44	0.47	1951 2012	1950	1999	1970
Scroafa	Saschiz	3.17	0.20	0.62	0.62	0.52	1950	1987	1981 1998	1970

The extent of variation of the annual discharge was outlined with the help of maximum and minimum module coefficients. The values of the maximum modular coefficient were between 3.22 and 1.63, and of the minimum module coefficient between 0.20 and 0.52 (table 27). The anthropic influence is seen on Târnava Mare at Zetea, through the smaller value of the maximum modular coefficient. The extent of variation of annual discharge is lower on rivers in the mountainous region, where humidity is higher throughout the year.

An important parameter in evaluating the variation of discharge over time is the coefficient of variation, whose values were calculated for three periods, noticing the fact that there are no great differences (table 27).

The differences of humidity between the mountainous region and the subcarpathian one are reflected in the values of the variation coefficients. The values of the variation coefficient are lower on rivers in the mountainous region, where the degree of humidity and afforestation is higher. The higher values of the variation coefficients reflect the uneven characteristic of discharge over time, which is mainly seen in the Subcarpathians rivers.

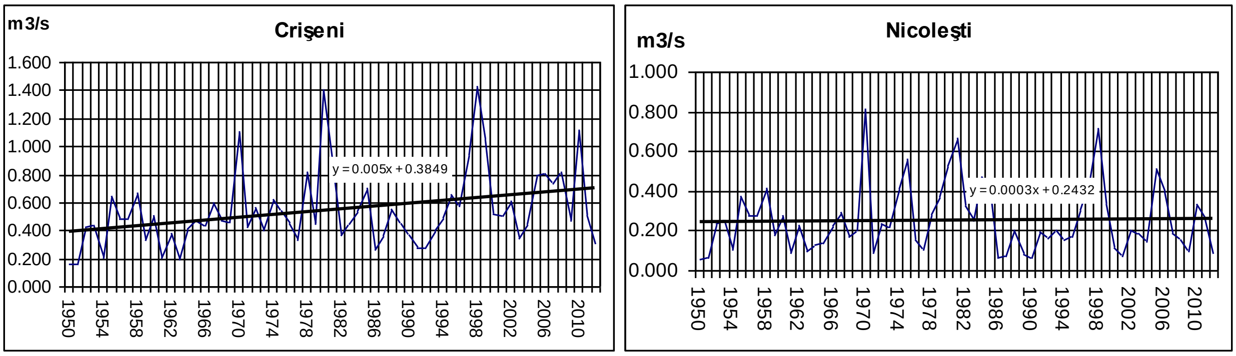


Fig.42.The chronological variation of annual average discharge.

In order to have a clearer view of the annual discharge variation we calculated average flows with various probabilities (table 29).

Table 29. Annual average flows with various probabilities

Brook	**Hydrometric station**	**Probabilities (%)**					
		0.1	**1**	**3**	**95**	**97**	**99**
Niraj	Cinta	13.001	9.147	7.384	2.294	2.294	2.286
Târnava Mică	Sovata	4.105	3.077	2.607	1.250	1.250	1.248
Târnava Mică	Sărăţeni	16.774	12.454	10.477	4.773	4.773	4.764
Cuşmed	Crişeni	2.194	1.515	1.204	0.307	0.307	0.305

Târnava Mare	Vărşag	16.802	10.808	8.066	0.151	0.151	0.140
Târnava Mare	Odrohei	15.140	11.257	9.480	4.352	4.352	4.345
Târnava Mare	Vânători	29.436	21.200	17.432	6.557	6.557	6.541
Şicasău	Şicasău	3.463	2.629	2.248	1.146	1.146	1.144
Hodoş	Nicoleşti	1.342	0.900	0.698	0.114	0.114	0.113
Feernic	Şimoneşti	3.253	2.282	1.837	0.555	0.555	0.553
Scroafa	Saschiz	2.803	1.889	1.471	0.264	0.264	0.262

In assessing the valorification possibilities of water resources, knowing the evolution tendency of water resources is of great importance. In this respect, for the 13 stations, we determined the evolution tendencies of annual average discharge for two periods.

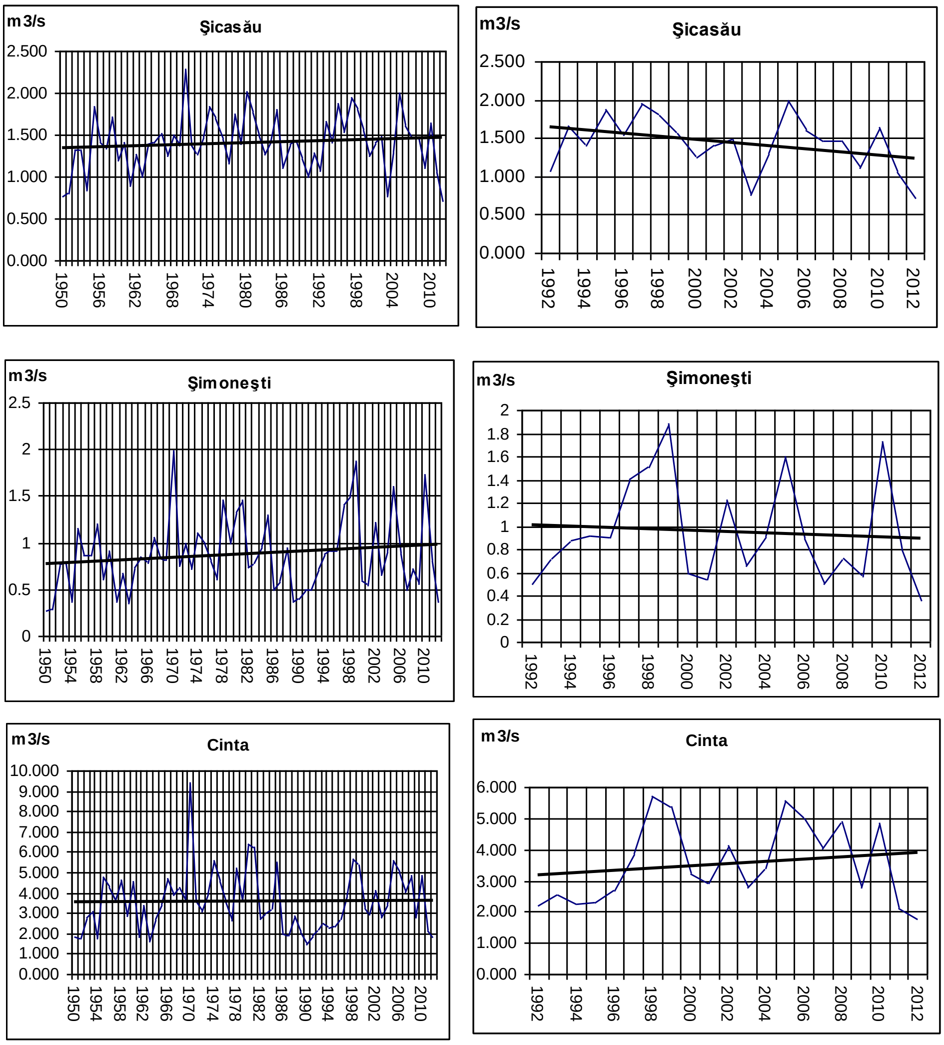


Fig. 43. The tendency direction of annual discharge from the periods 1950-2012 and 1992-2012

III.4.3. Water balance

In the structure of the hydric balance is comprised the rainfall (X) which is consumed in the formation process of surface discharge (S) and underground discharge (U) and through evapotranspiration (Z). The water resources remaining in the reception basins after the formation of surface discharge represent the overall moistening of the area (W = U + Z). In turn, superficial and undergound discharge form overall discharge (Y = S + U).

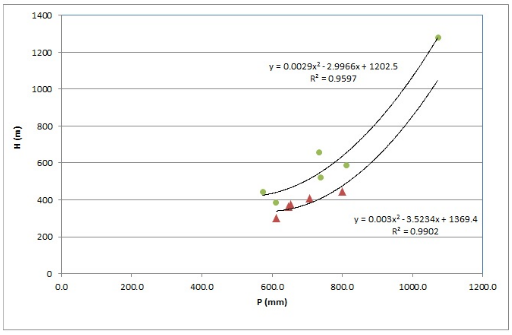
The assessment of multiannual average discharges of the components of the hydric balance was made on the basis of the differential equation drafted by M.I.Lvovici: $X_o = Y_o + Z_o$; $X_o = S_o + W_o = S_o + (U_o + Z_o)$, applied to the data resulted from measurements and determinations in the period 1992-2012, carried out at the meteorological and hydrological network in the studied area.

III.4.3.1. The spatial distribution of the components of water balance

The components of the hydric balance have a non-uniform distribution over time and space, linked to the geographic particuliarities of the studied region. The differentiations which appear in the spatial distribution of rainfall and discharge are especially caused by the particuliarities of air masses circulation and of relief, that is the advection of moist air masses from the west and the usual increase of relief altitude from west to east.

The rather diversified geological conditions require obvious differentiations in the storage possibilities of underground waters. The afforestation degree causes weak differentiations in the spatial distribution of the hydric balance components, which could not be assessed quantitatively for lack of observation data. Under such conditions, the main element we relied upon in the spatial analysis of the components of the hydric balance was relief altitude. The correlations between the average altitude of reception basins and the hydric balance components emphasize the basic laws of water resources formation in the studied area.

The analysis of the spatial distribution of the main components of the balance was carried out at the level of altitude layers, of the main hydrographic basins as well as of geographic subunits. The distribution of average quantities of rainfall (X_o) greatly condition the spatial variations of the other hydric balance elements.



The relations between the multiannual average quantities of rainfall and altitude emphasize two distinct connections (fig.46), which, from a territorial point of view, correspond to areas in which the increase of rainfall quantities as altitude increases occurs differently.

Fig. 46. The relation between multiannual quantities of rainfall and altitude

The first area corresponding to the hydrographic basins of Niraj and Târnava Mică is characterized by higher pluviometric gradients, due to the favourable exposure towards the advection of air masses from the west and of the intense orographical convection determined by the steep slopes in front of the subcarpathian peaks and Gurghiu Mountains.

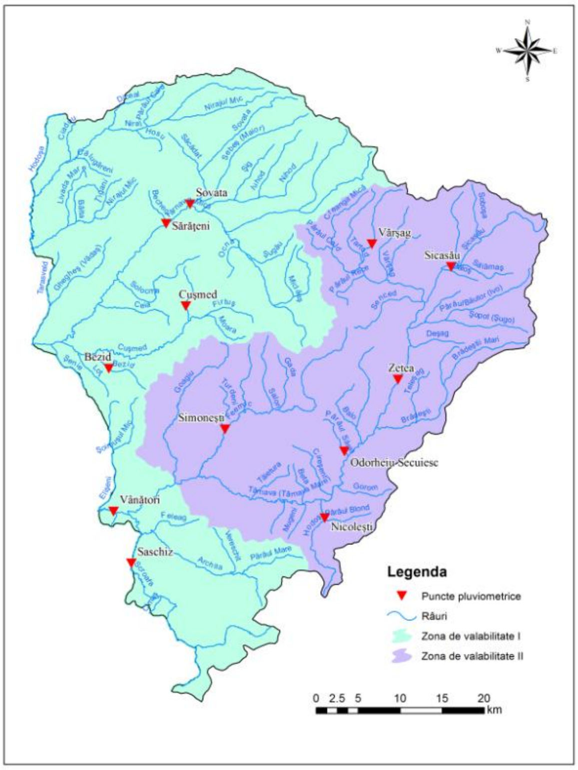


Fig. 47. Areas of validity of the relations X=f(H)

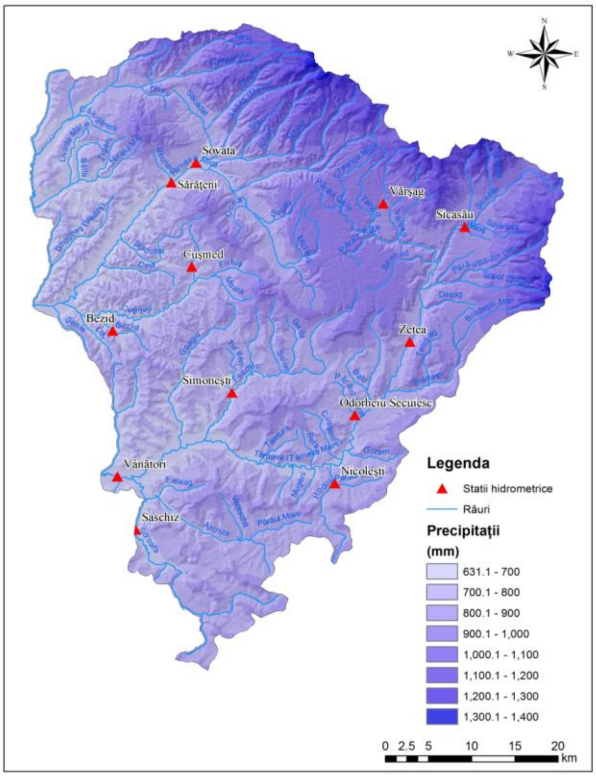


Fig. 48 The map of the distribution of annual average quantities of rainfall

Analysing the spatial distribution of rainfall at the level of the main geographic subunits we notice quite obvious differences. Thus, the lowest quantities of rainfall were determined for the Târnava Mare Subcarpathians (807mm). Somewhat higher values, over 830 mm, are characteristic to Târnava Mare Hills and Niraj Hills. At the level of the mountainous region, annual average rainfall exceeds 950 mm, being somewhat higher in Gurghiu mountains, than in Harghita mountains.

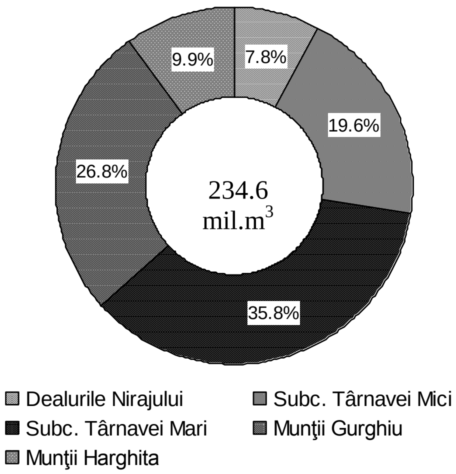


Fig. 49. The weight of each geographic subunit in the total rainfall water volume

The spatial distribution of rainfall water volumes depends greatly on the weight of surfaces owned by each subunit and altitude interval, as well as on the value of pluviometric gradients. Thus, the largest volumes of water are made in Târnava Mare Subcarpathians (35.8% of the total volume) and Gurghiu Mountains (26.8%).

The distribution of overall average discharge (Y_o) is also determined by the oro-aerodynamical conditions of rainfall and the influence of certain physical-geographic factors. Of those, relief is most influential, determining the altitude zonality noticed in the three areas with different discharge gradients. In the studied area, the multiannual average water volume originating in overall discharge was assessed to 579.94 million m ^{3}, value which corresponds to an average layer of 241 mm and a specific average discharge of 7.161 l/s. km^2,, value which greatly exceeds the country average.

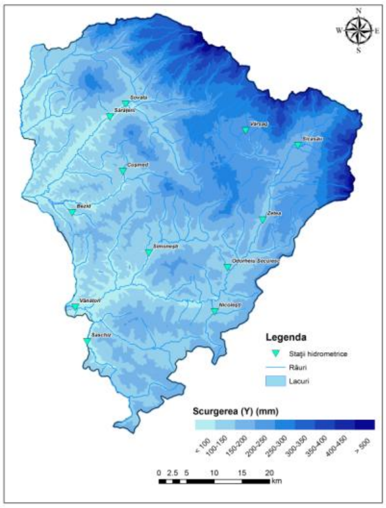


Fig.50. Map of fluvial average discharge (layer in mm)

From the analysis of the map of fluviatile average discharge there results that the layer of average discharge is maintained under 100 mm on the low relief steps in the subcarpathian region, from where they increase to 200-250 mm on the high hills peaks that close the depresionary corridor Corund-Săcădat.

In the mountainous region the layer of average discharge increases from the volcanic plateau (200-250 mm) towards the high areas corresponding to the volcanic cones, where values exceed 500 mm (fig.50).

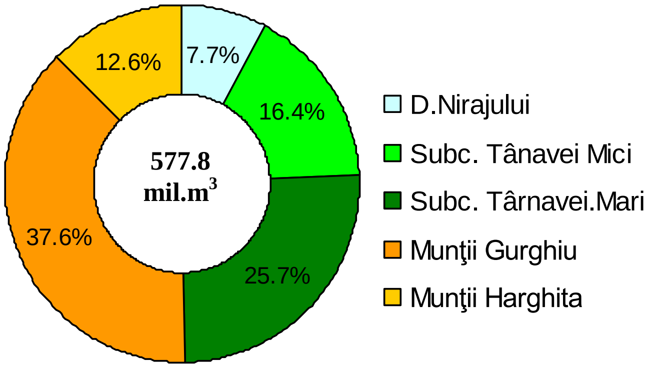


Fig. 51. The weight held by geographic subunits in the total volume of water from overall average discharge

The distribution of the layer of superficial discharge (S_0) obeys the same distribution laws mentioned in the case of global discharge. The values of superficial discharge are almost twice as high in the mountain region (284 mm in Gurghiu mountains and 210 mm in Harghita mountains) than in the Subcarpathian region.

Underground discharge (U_o) like the other elements of the hydric balance, exhibit a zonality conditioned by the increase of humidity and the intensity of the drainage from west to east and from the axis of the main valley corridors towards the interfluvial peaks. In the subcarpathian region, underground discharge is between 30 and 70 mm, whereeas in the mountainous region it is between 90 and 150 mm.

Evapotranspiration (Z_o) determined as a difference between average rainfall (X_o) and the layer of overall average discharge(Y_o) is mostly informative, due to the lack of data obtained from direct observations, which are influenced by the local conditions specific to each subunit (degree of afforestation, types of soil and cultures, exposition and slope of sides etc). The values of evapotranspiration oscilate between 550 and 675 mm.

The overall moistening of the soil (W_o) was obtained from the addition of underground discharge and the value of evapotranspiration, representing actually that part of the rainfall that is unable to be discharged at the surface of the soil. Thus, we notice the general tendency to diminish values from the east (725-750 mm) to the west of the studied area (700 – 725 mm).

III.4.3.2. Structure of the water balance.

The structure of the water balance was studied at different levels: globally, on hydrographic basins, on geographic units and subunits and at the studied hydrometric stations.

The overall hydric balance, determined for the whole studied area, can be expressed on the basis of the multiannual average values of the main components in the following manner: to the contribution we include 876 mm/year originating in rainfall, of which 241 mm are consumed in the formation processes of overall average discharge, and 635 mm through evapotranspiration. Of the overall average discharge assessed to 241 mm, surface discharge holds 170 mm, and the underground one 71 mm. There results the rather important participation of undergound resources to the overall moistening of the soil, which represents 706 mm.

The water balance on geographic units and subunits. From the analysis of the components of the water balance on gedographic units, we notice a more intense water circuit in the mountainous region than in the subcarpathian one, a fact which ensures the supplementation of water resources from areas lean from a hydric point of view, belonging to the Transylvanian Plateau. In this respect, we can mention the construction of the storage lakes from the mountainous region (Zetea storage lake) and from the Subcarpathian region (Bezid storage lake), which, among others, fulfill the function of supplying the settlements in the Târnave Plateau with drinkable water.

The water balance on the level of hydrographic basins calculated for the three main collectors does not emphasize any major differences regarding the structure of the three essential components. On the level of the main affluents there results the special influence that pluviogenetic conditions have, as well as average altitude and the surface of the reception basins.

Differences are smaller between the two intervals, which can be explained by the rather short series of the first period.

CHAPTER IV

RIVER WATER DISCHARGE REGIME

By hydrologic regime we refer to the **binding** change of water resources over time, conditioned by geographic factors.

IV.1. The sources of river supply

At high altitudes in the mountainous region, dominant is the melting of the snow. Pluvial supply is characteristic in May-July, when in the Subcarpathian region there occur beginning of summer freshets, and in the mountainous region there are high pluvio-nival summer waters. *The subbteranean supply* of rivers in the studied region represents between 25% and 35% of the total fluviatile discharge.

IV. 2. The distribution of the discharge during the year and the characteristic phases of the hydrologic regime

The distribution of the discharge during the year greatly determines the economic value of waters. The more balanced the hydrologic regime of water courses, the more efficiently and cheaply they can be used.

In order to elaborate the analysis of the discharge regime during the year, we have taken into account three periods: a long one (1950-2012) and two shorter ones (1970-2012). From the analysis of the data regarding the proportional values of participation of seasonal discharge to the realization of the annual average volume in the three periods, there are no visible important differences, the calculated values being fairly equal.

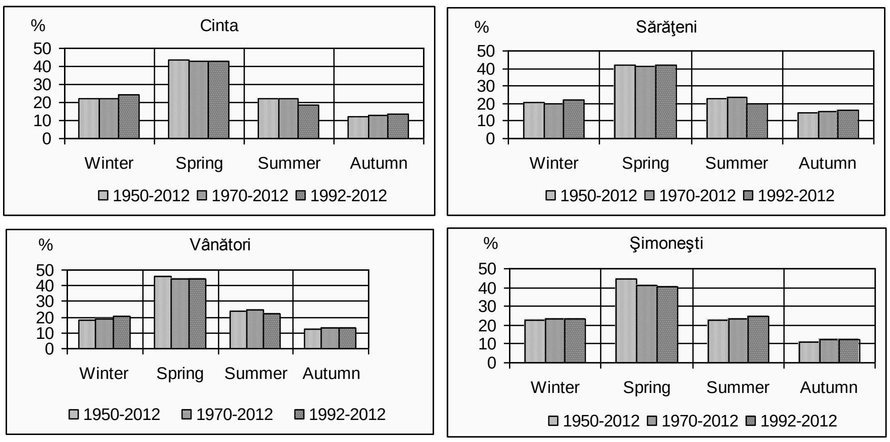


Fig. 57. The proportional values of seasonal discharge in the three studied periods.

IV.2.1. Seasonal discharge regime

We must note the fact that the weight of the spring discharge is bigger than that of other seasons. The proportional value of winter discharge of the rivers in the Niraj and Târnava Mare basins (21%-25%) exceeds the one in summer. Higher proportional values of spring discharge are encountered on Niraj, Bezid and on the right affluents of Târnava mare coming from Gurghiu Mountains (43% - 45% of the annual average volume). On most rivers, the richest spring discharge occurred in 1970, and the lowest in 1972.

The lowest proportional values of summer discharge are recorded in the Niraj and Târnava Mică basins (between 18% and 22% of the annual average volume), and the highest in the Târnava Mare basin (between 22.1% and 25%).

Autumn represents the season with the lowest contribution to the realization of the annual average volume (7.9% Scroafa at Saschiz and 17.7% Târnava Mică at Sovata).

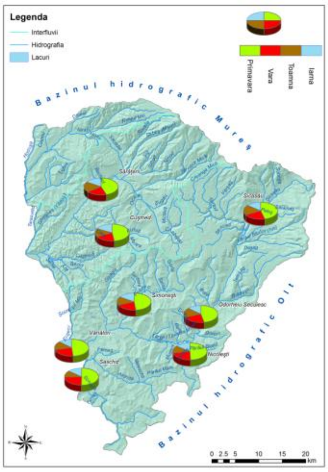


Fig. 62. Types of seasonal distribution of discharge

The types of seasonal distribution of discharge were set in relation to the succession of the seasons in decreasing order of their contribution to annual discharge, with the exception of spring, which is predominant on all rivers in the studied region. It has been noticed that the V.T.I. type is specific to rivers in the Târnava Mare basin, with the exception of a few affluents in the Subcarpathian region (Hodoșa and Scroafa). The V.I.T. type is specific to rivers in the hydrographic basins of Niraj and Târnava Mică.

The discharge variation over time was outlined with the aid of variation coefficients. In spring and winter, the lower values of this parameter reflect the more uniform characteristic of discharge distribution. Conversely, in summer and autumn, when the variation coefficients have the highest values, territorial differences are much more visible.

Table 44 . Linear tendencies of seasonal discharge

Brook	**Hydrometric station**	**Winter**	**Spring**	**Summer**	**Autumn**
Niraj	Cinta	St.	Sc.u.	Sc.a.	Sc.u.
Târnava Mică	Sovata	St.	St.	Sc.a.	Sc.u.
Târnava Mică	Sărăţeni	St.	Sc.u.	Sc.a.	Sc.u.
Cuşmed	Crişeni	Cr.u.	Cr.u.	Sc.u.	Sc.u.
Târnava Mare	Vărşag	Cr.a.	St.	Sc.u.	St.
Târnava Mare	Odorohei	Cr.u.	St.	Sc.a.	Sc.u.
Târnava Mare	Vânători	St.	St.	S.a.	Sc.u.
Şicasău	Şicasău	St.	Sc.a.	Sc.u.	Sc.u.
Hodoş	Nicoleşti	Sc.u.	Sc.a.	Sc.a.	Sc.a.
Feernic	Şimoneşti	Sc.u.	Sc.u.	Cr.u.	Sc.u.
Scroafa	Saschiz	Sc.u.	Sc.u.	Sc.a.	Sc.a.

St-staţionar, Cr.u.-creştere uşoară, Cr.a.-creştere accelerată,
Sc.u.-scădere uşoară, Sc.a-scădere accelerată

From the distribution of monthly average discharge throughout the year, we notice considerable territorial differences generated by climatic factors. Thus, in the basins of Hodoş and Scroafa brooks, where snow melts earlier due to the lower altitude of the relief as compared to the others, the maximum occurs in March. On most rivers, the maximum percentage of monthly discharge was signalled in April.

The month with the lowest average discharge is August in the case of rivers in the upper basin of Târnava Mică and of those in the Niraj basin, and on most other rivers in October.

The description of the daily discharge regime is made with the help of the type hydrograph drafted on the basis of the most frequent sizes, given by apparition and duration of the regime stages, materialized by the high spring waters, low summer waters, autumn freshets, low winter waters and winter freshets; the type hydrograph contains for each regime phase the external variation limits of the respective size, as well as the characteristic data of their occurrence.

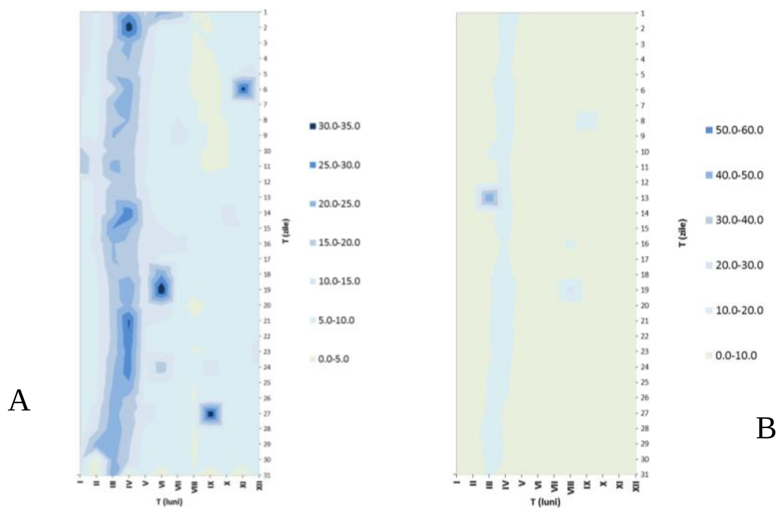


Fig. 69. Daily average discharge variation, within one year, for the interval 1196-2004
A-S.h. Vânători, B-S.h. Odorheiu Secuiesc

IV.3. Discharge stages

The characteristics of average discharge were presented within the previous chapter, therefore, in the present chapter we present solely the extreme stages of discharge in the studied area, the maximum and minimum discharge.

By high waters we refer to the stages in a river's life in which discharge is generally situated at high levels.

The freshet differs from high waters by a concentration of discharge over time, that is by relatively fast increases of water flows and therefore of levels, by reaching high flow peaks, and then by a relatively fast decrease of waters, which is, however, generally slower than the increase.

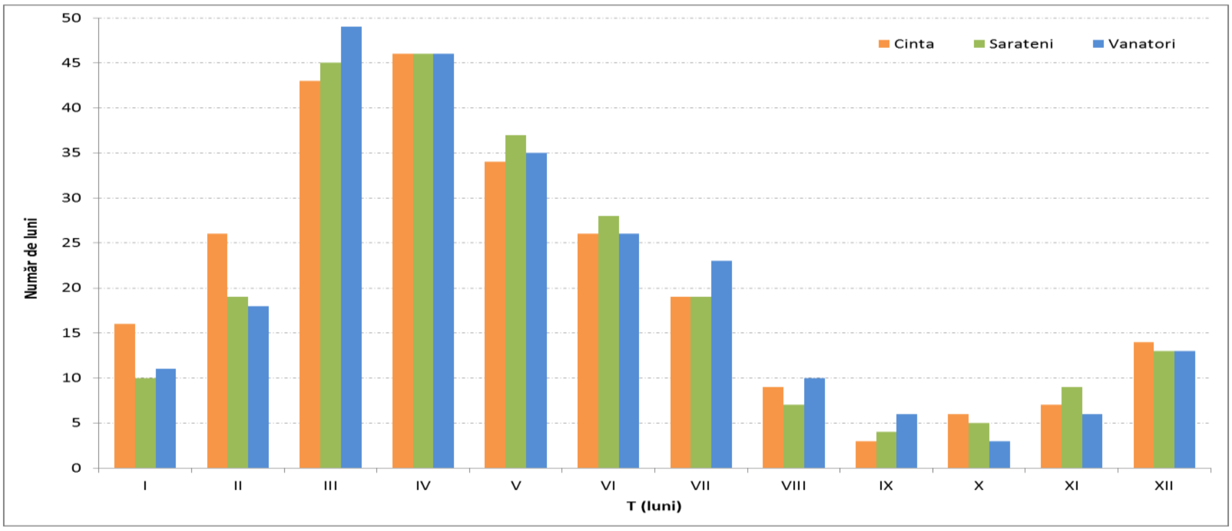


Fig. 70. Number of cases (months) in which the flow is higher than the multiannual average value.

The current specialized literature classifies freshet waves into two categories: **fast kinetics freshets and slow kinetics freshets.**

Another classification criterion of freshets is by their generating factor, supply source: nival, pluvio-nival, pluvial. By the existence of a single or more maximum flow peaks, there are: simple and compound freshets.

Regarding the genesis of freshets, when the disposition of affluents is in the shape of a fan, as in the Târnava Mare basin, upsream of Vânători (the affluents being disposed on both sides of the main course), the water reaches the main river almost simulatneously, which creates the proper conditions for the formation of a **concentrated freshet**. In the basins with an elongated form, like the Târnava mică or Niraj basins, the non-simultaneous arrival of water in the main river causes an intermittend increase in the flow.

The genesis of freshets is linked not only to the physico-geographical conditions, but also to the surface of the hydrographic basins. Thus, we noticed that for the small basins Hodoş (46 km²), Sovata (84 km²), Feernic (145 km²), Sicasau (147 km²), the highest flows are caused by torrential rainfall, while in the case of larger basins Târnava Mare (1600 km², upstream of Vânători), Niraj (555 km², upstream of Cinta), Târnava Mică (461 km², upstream of Sărăţeni), their weight decreases due to the balancing role that large basins have, but, instead, increases the role of long-term rainfall and of the melting of snow.

The winter freshets are caused both by the melting of snow, as well as by liquid precipitations, determined by the rather frequent invasions of hot ocean air masses from the north-west, and intensified by the configuration of the relief, by frontal processes. Such a case was signalled in December 1995, when the maximum flow was 213 m^3/s at Sărăţeni, 615 m^3/s at Vânători, 107 m^3/s at Odorhei, 43 m^3/s at Zetea, 85 m^3/s at Vârşag, 78 m^3/s at Saschiz, 76,2 m^3/s at Şicasău, 71 m^3/s at Simoneşti, or 4,55 m^3/s at Nicoleşti on Hodos.

Table. 47 The monthly proportional frequency of freshetsin the period 1982-2005

Hydrometric post	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
CINTA	3,8	0,0	**26,9**	**26,9**	7,7	11,5	7,7	7,7	3,8	0,0	0,0	3,8
NICOLESTI	0,0	7,3	14,6	**22,0**	9,8	14,6	14,6	12,2	0,0	0,0	0,0	4,9
SIMONESTI	2,4	7,3	**17,1**	14,6	9,8	**14,6**	12,2	7,3	4,9	2,4	2,4	4,9
SICASAU	0,0	2,2	**17,4**	**17,4**	13,0	**17,4**	13,0	8,7	4,3	4,3	0,0	2,2
SASCHIZ	0,0	4,8	16,7	14,3	14,3	**19,0**	14,3	7,1	7,1	0,0	0,0	2,4
VARSAG	0,0	3,4	23,7	**27,1**	8,5	6,8	10,2	5,1	11,9	1,7	0,0	1,7
ZETEA	0,0	3,7	22,2	**29,6**	18,5	7,4	3,7	7,4	0,0	0,0	3,7	3,7
ODORHEI	0,0	4,7	**30,2**	25,6	16,3	4,7	4,7	7,0	2,3	0,0	2,3	2,3
VANATORI	2,9	0,0	17,1	**25,7**	14,3	8,6	5,7	8,6	5,7	2,9	5,7	2,9
SARATENI	0,0	3,7	11,1	**37,0**	7,4	14,8	3,7	7,4	3,7	7,4	0,0	3,7

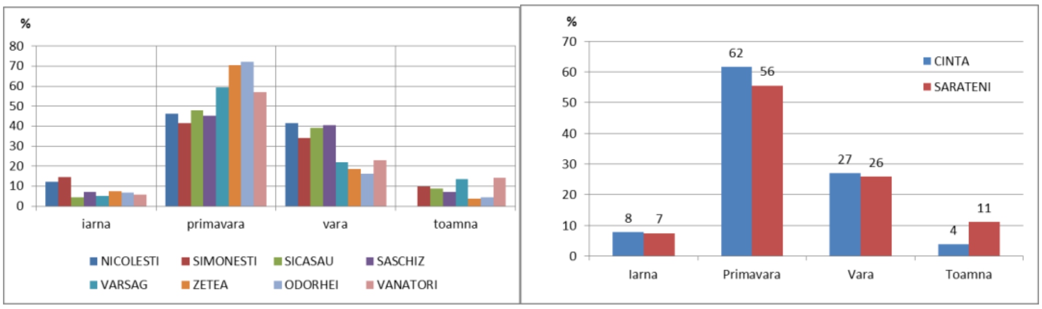
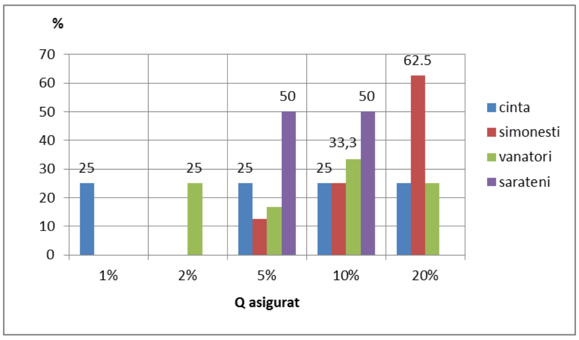


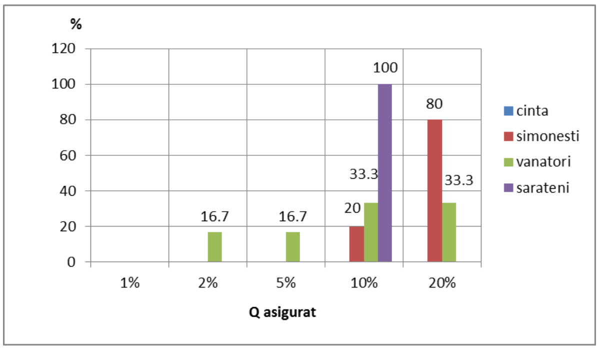
***Fig. 73** The seasonal frequency of freshets in the period 1982-2005, in the Târnava Mare basin (left) and Târnava Mică basin (Sărățeni) and the Niraj basin (Cinta) (right)*

In the period 1970-2005 there were 34 recorded freshets which exceeded the alarm levels at Cinta, 83 at Simonești, 9 at Vânători and 37 at Simonești. Of the 34 freshets on Niraj, 10 reached and exceeded the flood level, and 23 reached the danger level. On Feernic, the statistic data shows that 91.6% of floods exceeded the danger level of 150 cm. This shows us that the river

Feernic has a very fast reaction time to the factors external to the system, and the current hydrotechnical operations are outdated, the flood risk being very high.



A



B

Fig. 82 The frequency of reaching and exceeding the ensured flow in the period 1970-2005 (A) and 1982-2005 (B)

It has been noticed that in the past 23 years there have not been any recorded exceedings of the ensured flow of 1% at any station, and the exceeding of flows with the 2% and 5% has greatly decreased, there being a few cases only on Târnava Mare.

After the analysis of a few representative freshets, precise data which can be found in the Ph.D. thesis, we must emphasize the fact that, in some extreme meteorological and hydrological situations, the total elimination of risks and damage caused is not possible. The effects of these natural phenomena could be diminished solely by investments (automated meteorological and hydrological warning systems, storage lakes, protection dams, the considerable increase in the transport capacity of river beds) with great financial efforts in each small hydrographic sub-basin.

IV.3.1. Periods of low discharge

In the studied area, these periods are characteristic to autumn. The periods of low discharge at the end of the warm period of the year is a consequence of the low frequency of rainfall in August – September and of the stiil high evaporability on the surface of the soil.

The draining of rivers is more frequent in regions with lower altitudes, but only in the cases of rivers with small basinal surfaces. After the period of the apparition of minimum discharge of rivers during the year, we can state that the analyzed region is included in the summer and autumn periods of minimum discharge occurrence.

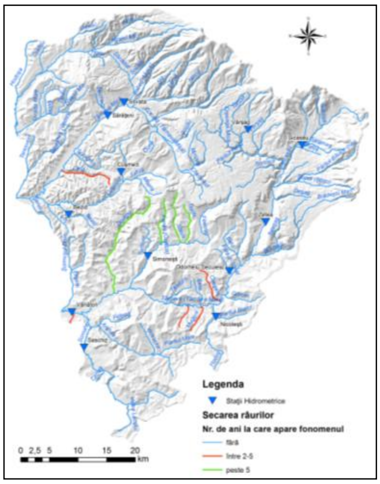


Fig. 95 The map of river drainings (never, once every frew years, rarely) by „Atlasul secării pe râurile din România“ 1974 with amendments

IV.4. Types of regime

Of the Carpathian regime types, in the studied region we encounter the Transylvanian Carpathian type, which includes the rivers with their origin below the altitudes of 1600-1800m whose supply type is pluvio-nival and moderately subterranean. The main feature of this type of regime is the rather early beginning of high spring waters, which last for 1-2 months (March-April). This period is followed by the freshets in the beginning of summer. Autumn freshets have a rather high frequency. At altitudes above 1000 m, minimum discharge occurs in winter.

The type of Transylvanian Pericarpathian regime is characteristic to the Subcarpathian region, where the effects of latitudinal zonality are felt stronger than those of altitudinal zonality. This type of regime is characterized by short-term nivopluvial high waters in March, and freshets especially in May-July. Feeding is pluvio-nival, and the continentality of the regime increases from north to south.

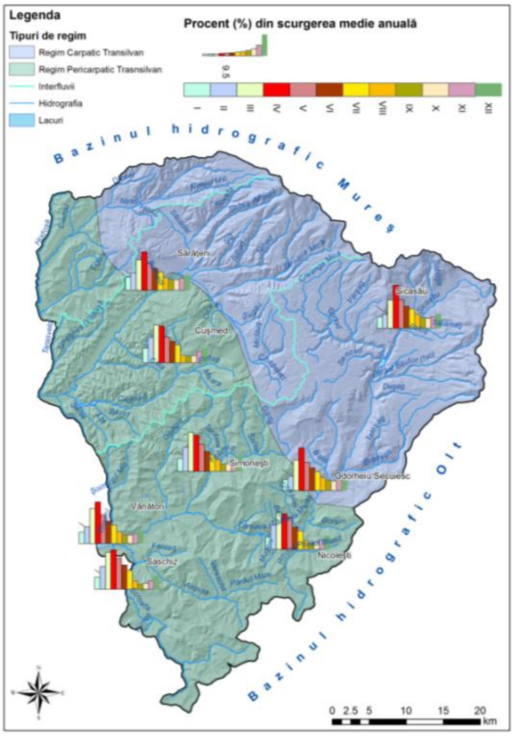


Fig. 97 Types of discharge regime

CONCLUSIONS

Assessing water resources together with the analysis of the discharge regime represent very important purposes from the point of view of balanced socio-economical development. At the same time, they are based on the variability of hydrological elements in time and space. Moreover, knowing the rules which covern the evolution of water resources is based on the identification of the causal physical and geographical factors and of the dependence relations between the components of the environment.

Considering the fact that the studied region represents a transition area, both as its position among hydrographic basins, and also as hydrological regime, between the mountain and the plain regions, in order to encompass as accurately as possible the particuliarities of liquid discharge, with all its aspects (average, minimum, maximum), and especially of the various connections to causal factors, we have used data provided by hydrometric stations situated both in the studied aream as well as in the neighbouring relief units.

After identifying the functional or correlational relations between factors and components, we have drawn the conclusion that the main role in the formation of natural discharge regime is attributes to climatic factors, which determine the quantitative and temporal variations of the water resources of rivers. The other components of the environment (geology, relief, vegetation and soil) play a secondary part, representing the general background against which rivers are formed. In the general system of interactions between the geosystemic components, the role of the antropic factor has become more and more poignant, lately becoming event determinant both in the formation of water resources, as well as in the setting of the hydric regime.

With the help of the SIG programs and of the spatial analyses of the digital model of the elevation of the studied area, we were able to extract the main factors of relief which play an important part in the formation of resources from the area. Thus, in what concerns the orientation of the mountain sides we observe the fact that the greatest percentage is owned by the sides with south-western and western exposure (13.9% and 14.1% respectively), after which follow the sides with north-western (13.5%) and southern (13.1%). The presence of the Carpathians in the eastern part of the studied region causes a complex process on the air masses and on the respective baric structure, which is manifested by obstructing them, either by changing trajectories, or by disturbing the vertical structure of the baric field. The orientation of mountain masses greatly influences the frequency and quantity of rainfall in a certain region. Thus, on the sides of the mountain masses which are oriented to the west and north, the multiannual average of rainfall is higher than on the eastern sides at the same altitude. On the western and northern slopes of these mountain masses there occur frontal and advective processes which frequently activate the formation of clouds and heavy rainfall.

The climate of the area is partly similar to the submountainous characteristics of high hills, exposed to western and north-western winds, and partly to the mountainous climate of middle-sized and short mountains, and at over 1700 m to the tall mountains climate. Following the proportional variation of seasonal rainfall within the basin, we notice that summer rainfall dominate clearly, followed by spring and autumn rainfall at almost equal percentages.

During the summer there occur torrential rainfall, whose effects are harmful by the sudden level changes, changes of water courses, intensifications of soil erosion. As a consequence of the influence of moist ait masses from the west, precipitations in the form of rain are manifested during winter as well, leading to significant increases in flow.

Together with liquid precipitations, snowfall constitutes an important reserve of water which accumulates on the soil during winter, in the shape of the snow layer. Owing to its physical properties, the layer of snow influences the thermal regime of the air, causing the lowering of air temperature and thus favouring the intensification of thermal inversions.

The presence of two areas (Carpathians and Subcarpathians) on the studied region, which span on an altitude difference of over 1000 m constitutes the cause of the changes in certain climatic conditions which in turn cause an obvious layering of natural vegetation according to altitude. Thus, we can distinguish between two distinct areas, that of the forests and the alpine one. From a hydrological point of view, of a greater importance is the influence of forest vegetation on discharge. The correlation between the degree of afforestation on Târnava Mare and Târnava Mică are relatively closer and lower in the Niraj basin.

Through its hydrological function, forest vegetation imprints a stability of the discharge regime, both of surface as well as underground waters, emphasized mostly by the alleviation of maximum discharge (in periods which are in pluviometrical excess) and the increase of minimum discharge (in periods which show a pluviometrical deficit). Beside the generally valid consequences, the results of certain studies carried out in the Târnava Mare and Târnava Mică basins allow the drafting of quantitative conclusions. It has been observed that at average basinal altitudes between 500 and 900 m and reception surfaces larger than 400 km^2, a 5% increase in the afforestation coefficient generates the increase of annual average discharge with 1 ls.km^2, and of the minimum monthly discharge with approximately 0,4 1 ls.km^2 . Likewise, we observed the fact that the total average durations of floods are higher than those on Târnava Mare, in sections situated at equal distances from the spring.

At the same time as being a plain athropic component, the permanent accumulations built on Târnava Mare (Zetea) and Cuşmed (Bezid) were built with the purpose of diminishing the flood waves during periods of high waters, of supplementing flows in periods of low waters, of supplying water to various consumers downstream and to a smaller extent, for the production of electrical energy. From the total volume of permanent storage lakes, the highest weight is carried by volumes reserved for reducing flood waves.

By means of the spatial analysis we also assessed the density of the hydrographic network which represents the ration between the total lengths of the hydrographic systems to the surface unit (km/km^2). As it is well known, this is a parameter which offers a good image of the degree of relief fragmentation, thus quantifying the type of surface variation. Calculations show that 61.0% of the basin surface has values below 0,5 km/km2 (Fig. 36). The highest value reaches 4.8 km/km^2, but covers an area of only 0,01 %. Surfaces with values of 1-1,5 km/km^2 represent 14% of the surface. The average value of the density of the fragmentation is 0,61 km/km^2.

In order to assess the water resources of rivers and their discharge regime, we examined and processed series of daily, monthly and annual average flows coming from 13 hydrometric stations, whci control hydrographic basins whose altitude oscillates between 570 and 1.021 m, and whose surface is between 15 km^2 and 1771 km^2.

For the description of water resources on a certain territory and comparing them to other geographic units, we chose to use specific average discharge which represents the quantity of water discharged on the surface unit (km^2) during one second (s). It is obtained by relating the river flow in a given section to the appropriate basin surface. The values thus obtained were correlated tith morphometrical elements of the reception basins. The closest correlations were obtained with average altitude, which allowed for the territorial generalization of the values of annual average discharge. The identification of the area of validity of the relations q=f(Hm) permitted the assessment of annual average discharge on the level of main rivers and geographic units. The correlation between specific average discharge values and average altitude of the reception basins of the studied hydrometric stations allowed us to identify three validity curves.

The three identified correlation curves correspond to three areas in which discharge is produced differentiatedly. In general, one can observe a decrease of the discharge gradients from north to south depending on the reduction of rainfall quantities in the same direction and of the exposure of the area towards the advection of moist air masses from the west.

Depending on the discharge conditions specific to each area of validity of the relation q=f(Hmed), the increase of discharge in ratio to altitude is produced differentiatedly.

Based on the data obtained after the correlation between altitude and specific flow, we drafted the map of specific average discharge, from which results an increase of values from 4 l/s. km^2 at the meeting point of the Subcarpathians with the Transylvanian Plateau, to 18-20 l/s. km^2 on the high peaks of Gurghiu and Harghita.

The total average flow of rivers in the studied region was evaluated to 20.613 m3/s. The average flows of rivers differ depending on the geographic conditions, the size and exposure of hydrographic basins.

The map of average multiannual rainfall, drafted on the basis of the relations X = f (Hm) emphasizes the altitude zonality of this climatic element. Thus, the lowest quantities of precipitations fall on low layers of relief from the meeting point of the Subcarpathians with the Transylvanian Plateau and in the Subcarpathian depressionary areas (600 – 700 mm), from where they can reach as high as 1000 – 1100 mm on the high Subcarpathian peaks. In the space corresponding to the mountainous region, the quantities of rainfall increase from the volcanic plateau (1000- 1100 mm) up to 1300 – 1400 mm on the high peaks of Gurghiu and Harghita mountains.

The global hydric balance, determined for the whole studied region, can be expressed on the basis of the multiannual average values of the main components in the following manner. To the contribution we add 876 mm/year, originating in rainfall, of which 241 mm are consumed in the formation processes of global average discharge, and 635 mm in evapotranspiration.

Of the global average discharge assessed at 241 mm, surface discharge comprises 170 mm and the underground one 71 mm. There follows that underground resources participate rather extensively to the global moistening of the soil, which represents 706 mm. The high values of subterranean discharge are determined by the rich moistening in mountainous spaces and by the presence , on rather large areas, of permeable deposits which offer optimum conditions for the accumulation of the water resource coming from rainfall and melting of the snow layer.

In order to elaborate the analysis of the seasonal discharge regime, we took into account three periods: a long one (1950-2012) and two shorter ones (1970-2012 and 1992-2012). The latter has allowed for the harnessing of data coming from a number of 13 representative hydrometric stations. From the analysis of data regarding proportional values that seasonal discharge has in fulfilling the annual average volume in the three periods, there are no noticeable differences, the calculated values being fairly equal We can mention a few aspects that are specific to the analyzed periods, determined by the climatic changes in the three compared periods. Thus, the instability of winters in the interval 1992-2012 is seen in the fact that the proportional values of winter discharge were somewhat higher than those in the periods 1950-2012 and 1970-2012.

From the analysis of the three periods, one can also notice the fact that on all rivers dominant is spring discharge, and the lowest weight of the annual average volume is carried by autumn and winter.

The discharge variation over time was emphasized by means of variation coefficients. In spring and winter, the lower values of this parameter reflect the more uniform feature of discharge distribution. Conversely, in summer and autumn, when the variation coefficients are at their highest values, regional differences are much more visible. Thus, there appear rather obvious contrasts between the rivers in the Niraj and Târnava Mică basins on the one hand, and those in the Târnava Mare basin, on the other hand.

The distribution of discharge over the year greatly determines the economic value of waters. The more balanced the hydrologic system of waters, the cheaper and more efficiently they can be used.

The tendency of seasonal discharge evolution in the period 1970 – 2009 exhibits great territorial diversity, being determined by natural factors (especially the climatic ones) and by anthropic ones. In winter, on most rivers, the stationary feature of discharge is emphasized. The slight increase tendency of winter discharge was determined on Târnava Mare at the hydrometric station Odorhei, and was seen as rather high at Vărșag. The slight decrease tendency of discharge was encountered on Hodoș, Scroafa and Feernic.

Territorial differences are also emphasized from the analysis of average discharge distribution for each month. Thus, in January, the precipitations that occur mostly in solid form and the conditions unfavourable for their melting determine low values of the discharge, which represents between 5% (Șicasău) and 7.7% (Crișeni) of the annual volume. Rather obvious contrasts exist between the rivers in the Subcarpathian region and the mountainous one, where proportional values are lower.

From the analysis of the freshets there results that most of them are recorded during the spring, both in the basins in the mountainous region, as well as those in the adjacent Subcarpahian area. The farther that hydrologic basins are from the mountain, the lower the weight of snow water supply is, which explains the increase in the number of freshets recorded during the summer, mainly caused by convective rainfall.

After comparing the statistical data from the interval 1970-2005 and 1982-2005 we notice a reduction of the frequency of exceeding the Flood Danger Level on all four posts, the difference being taken by the Flood Level and the Attention Level. In other words, we can distinguish an obvious impact of the hydrotechnical measures of prevention and controlling the floods in the studied area.

In the past 23 years there have been no exceedings of the assured flow of 1% on any post, and exceeding the flow with 2 and 5 % hassignificantly decreased, the sole few cases being on Târnava Mare. On the basis of the experiences gained during floods, we can conclude that the hydrotechnical system of defense actually works, but that the local defense systems on affluents are not capable of eliminating the potentially catastrophic situations and of diminishing material damage. Among other things, it has been proven that:

- the maintenance of brook beds was not appropriate to the necessities;
- sections of bridges on the brooks affected by freshets are undersized and produce backwater;
- mayoralties generally didn't have the instruments necessary for carrying out the protection work needed;
- although weather forecasts had been made, they were not accurate enough in in order to take operative measures, and the system for warning the population didn't work well enough
- the inhabitants didn't trust the warnings issued by the authorities and did not leave the houses in the endangered locations in time;
- in the region there was no working weather radar, which could have detected torrential rain in time;
- in the affected hydrographic basins there exist no automated pluviometric or hydrometric stations, and for lack of data, we do not know the exact quantities of precipitations that fall.

However, we must underline the fact that, in some extreme meteorological and hydrological situations, the total elimination of risks and damage caused is not possible. The effects of these natural phenomena could be diminished solely by investments (automated meteorological and hydrological warning systems, storage lakes, protection dams, the considerable increase in the transport capacity of river beds) with great financial efforts in each small hydrographic basin.

In the following chapter, the characterization of minimum discharge was made by means of minimum modular coefficients, which are obtained as a ratio between the lowest flow recorded in a given period, and the annual or multiannual average flow. For the low water flow, there is an estimated minimum modular coefficient with values between 0.0 and 0.5 and a specific average discharge of below 1 l/s. km^2.

On the basis of the graphic relations between minimum discharge and medium altitude of reception basins, we can draw the conclusion that the highest values of minimum discharge (7-10 l/ s km^2) are met in the alpine areas, mountains being characterized in general by izorelee of 1-5 l/s km^2 and decrease towards the Transylvanian Plateau (below 0,1 l/s km^2).

Regarding the natural discharge regime within the studied area, of the Carpathian types, here we encounter the Transylvanian Carpathian type, which includes rivers with the spring below 1600 – 1800 m altitude, whose type of feeding is pluvio-nival and moderately subterranean. The main feature of this type of regime is the relatively early start of hugh spring waters, which last 1-2 months (March-April). This period is followed by the freshets in the beginning of summer. Autumn freshets are rather highly frequent.

At altitudes of above 1000m, minimum discharge is produced in winter. The type of Transylvanian Pericarpathian regime is characteristic to the Subcarpathian region, where the effects of latitudinal zonality are felt more than those of altitudinal zonality. This type of regime is characterized by dhort-term nivopluvial high waters in March, and freshets especially in May-July. Feeding is pluvio-nival, and the continentality of the regime increases from north o south.

In both cases, the supply of the discharge is a mixed one, being supplied both from the liquid precipitations that fall throughout the year, as well as the solid ones during the winter. The main difference is felt in the appearance of the annual maximum, thus, out of the nine stations analyzed, three record their maximum flows in March (Simonești, Atid and Nicolești) all of them representing small hydrographic basins in the Subcarpathian area, and the other six record their maximum a month later, in April, these being small basins in the mountainous area, or large basins made mostly of this type of basins. The explanation must be searched in the variation of resources with the altitude of the respective basin, since snow melts faster at low altitudes.

The studied region represents, through the water courses that drain it, a reservoir of variable humidity – rather rich, in a climate less favourable to agriculture (partially fragmented relief). Under such circumstances, the analyzed hydrographic basins can constitute rich sources of irrigation and of ensuring the necessary water resources in periods when the water supplies are low, upstream the region.